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# (54) Video telecommunication system and method for compressing and decompressing digital colour video data

Videofernmeldesystem und -verfahren zur Kompression und Dekompression von digitalen Farbvideodaten

Système et méthode de télécommunication vidéo de compression et de décompression de données vidéo couleur numériques

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**Description**

BACKGROUND OF THE INVENTION

Field of the Invention:

This invention relates generally to information signal processing, and in particular to the field of processing time sequential information signals, such as video signals, for the purpose of reducing the amount of information to be transferred from an encoding site to a decoding site. A particular use of the invention is in the communication of color video data over telephone lines for purposes of video telecommunications.

Prior Art:

Encoding of digital television signals ordinarily requires a transmission rate of approximately 200 Mbits/s. Recent developments in coding systems have permitted the transmission rate to be cut to less than 2 Mbits/s. Coding systems using block oriented analysis of video picture frames and processing by a conventional hybrid discrete cosine transform (DCT) coefficient permit transmission at rates of between 64 Kbits/s and 384 Kbits/s. Such a system is described in Gerken and Schiller, "A Low Bit-Rate Image Sequence Coder Combining A Progressive DPCM On Interleaved Rasters With A Hybrid DCT Technique", IEEE Journal on Selected Areas in Communications, Vol. SAC-5, No. 7, August, 1987. Adaptive coding techniques applied to such DCT processing have allowed video data transmission at rates as low as one to two bits per pixel, as is described in Chen and Smith, "Adaptive Coding of Monochrome and Color Images", IEEE Transactions on Communications, Vol. COM-25, No. 11, November 19, 1977. However, information transmitted at such low data rates seriously affects the ability to reconstruct a sufficient number of frames per second so that a real time picture is acceptable to a viewer. High capacity telephone lines are available which will carry transmissions at a rate of up to 1.544 Mbits/s, but such lines are extremely expensive at a dedicated use rate, and are still quite expensive at a scheduled use rate. Lower capacity telephone lines are available which permit transmission at rates of up to 56 Kbits/s and 64 Kbits/s. Relatively expensive video digital and coding devices are commercially available which will transmit a video signal at 56,000 bits per second, so that it is necessary to utilize a combination of a device of this nature with the high capacity 1.544 Mbits/s telephone line to allow a framing speed much faster than about one frame per second. The current transmission rate limit of ordinary telephone lines approaches 18,000 bits per second, so that transmission of real time sequencing of video pictures over ordinary telephone lines has been viewed in the prior art as not being feasible.

Various schemes for reducing the amount of redundancy of information to be transmitted in a digital video signal have been used. One technique is to utilize a slow scan camera; and another technique is to transmit every nth scanning line for each frame. Another technique involves the sending of only those parts of a picture frame which are deemed to be important or to have changed in some significant manner, by dividing the picture frame into a number of segments or blocks which are typically 3X3 or 4X4 groups of pixels, and analyzing the content of the blocks. These techniques tend to also reduce the resolution of the video picture.

Another technique in the reduction of transmission time which does not decrease the resolution of a picture transmitted is run length encoding. In run length encoding, the scan lines of a picture frame are encoded as a value of the color content of a series of pixels and the length of the sequence of pixels having that value or range of values. The values may be a measure of the amplitude of a video signal, or other properties of such video signals, such as luminance or chrominance. An example of a system which utilizes run length coding of amplitude of video signals is U.S. Patent US-A-3,609,244 (Mounts). In that system, a frame memory also determines frame to frame differences, so that only those differences from one frame to the next are to be transmitted. Another example of a method for transmitting video signals as compressed run length values which also utilizes statistical coding of frequent values to reduce the number of bits required to represent data is U.S. Patent US-A-4,420,771 (Pirsch).

Ideally, compression of color video information to allow real time sequencing of picture frames at a rate of up to 15 frames per second, and at bit rates as low as 11,500 bits per second would be desirable, to allow the communication of color video data over ordinary telephone lines. A video data compression system able to achieve equivalent data transmission rates as systems using higher quality telephone lines with more efficient and less costly equipment than is currently available would also be desirable.

A compression technique is disclosed in FR-A-2524740 in which video signals are coded as segments in two dimensions to form a block taking into consideration not only pixels of the same scan line but also pixels of adjacent scan lines. Colour video data is compressed using this technique to separately code the luminance value Y and the two chrominance values B-Y and R-Y. There is no disclosure of providing for combined color compression nor of the concept of further compressing the color code segments.

SUMMARY OF THE INVENTION

According to one aspect, the present invention provides a method of compressing digital color video data comprising a color video signal for a plurality of video picture frames, with each picture frame comprising a plurality of scan lines composed of a plurality of pixels,

and each pixel in said picture frame comprising three digital color components, said method comprising the steps of:

a) determining a luminance value for each pixel as a function of at least one of said three digital color components;
b) evaluating at least one decision parameter for each pixel of at least a substantial portion of each of a plurality of scan lines of a current picture frame, by determining the difference between the luminance value of each pixel and the luminance value of at least one other pixel of the same scan line;
c) comparing said at least one decision parameter for each pixel with a corresponding adjustable threshold value to determine which pixels have a luminance value which is changed from the luminance value of said at least one other pixel by more than a predetermined amount, each of said pixels having such a changed luminance value being either a starting pixel or an ending pixel for a run length of sequentially related pixels in a said scan line, said run length being represented as a first part of a digital signal, said first part having a first digital word size, each pixel in each run length being defined to have the same three digital color components, said three digital color components being second, third and fourth parts of said digital signal having second, third, and fourth digital word sizes, respectively;
d) encoding said three digital color components of each run length in said picture frame according to a look-up table of compressed digital color codes of a fifth digital word size smaller than the sum of said second, third and fourth digital word sizes; said compressed digital color codes representing a selected number of color combinations, said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame, said encoding step comprising the step of selecting the compressed digital color codes representing the best match between said digital color components of each run length and said selected number of color combinations;
e) encoding the three digital color components of each set of said sequentially related pixels as a combination of the run length and associated said compressed digital color codes;
f) comparing said run lengths and said compressed digital color codes of said current picture frame with the run lengths and compressed digital color codes of a previous picture frame to determine changes from said previous picture frame to said current picture frame; and
g) encoding said changes from said previous picture frame to said current picture frame for at least a portion of said picture frames, whereby once an initial picture frame is encoded, only changes in subsequent picture frames are encoded.

According to a second aspect, the present invention provides a system for compressing digital color video data comprising a color video signal for a plurality of video picture frames, with each picture frame comprising a plurality of scan lines composed of a plurality of pixels, and each pixel in said picture frame comprising three digital color components, said system comprising:

a) means for determining a luminance value for each pixel using at least one of said three digital color components;
b) means for evaluating at least one decision parameter for each pixel of at least a substantial portion of each of a plurality of scan lines of a current picture frame, by determining the difference between the luminance value of each pixel and the luminance value of at least one other pixel of the same scan line;
c) means for comparing said at least one decision parameter for each pixel with a corresponding adjustable threshold value to determine which pixels have a luminance value which is changed from the luminance value of said at least one other pixel by more than a predetermined amount, each of said pixels having such a changed luminance value being either a starting pixel or an ending pixel for a run length of sequentially related pixels in a said scan line, said run length being represented as a first part of a digital signal, said first part having a first digital word size, each pixel in a said run length being defined to have the same three digital color components, said three digital color components being second, third and fourth parts of said digital signal having second, third and fourth digital word sizes, respectively;
d) means for encoding said three digital color components of each run length in said picture frame according to a look-up table of compressed digital color codes of a fifth digital word size smaller than the sum of said second, third and fourth digital word sizes; said compressed digital color codes representing a selected number of color combinations, said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame, said encoding means comprising means for selecting the compressed digital color codes representing the best match between said digital color components of each run length and said selected number of color combinations;
e) means for encoding the three digital color components of each set of said sequentially related pixels as a combination of the said run length and associated said compressed digital color codes;
f) means for comparing said run lengths and said compressed digital color codes of said current pic-

ture frame with the run lengths and compressed digital color codes of a previous picture frame to determine changes from said previous picture frame to said current picture frame; and

g) means for encoding said changes from said previous picture frame to said current picture frame for at least a portion of said picture frames, whereby once an initial picture frame is encoded, only changes in subsequent picture frames are encoded.

In a preferred embodiment of the method and system for data compression the digital color component signals are RGB, and the color component word sizes are equal. In one preferred embodiment the rate of change of the differences in luminance between pixels is determined and compared with a predetermined, adaptive threshold value. The digital word size of the digital color components is preferably initially six bits per each component color, and the luminance function is determined with an accuracy based upon the six bit digital color values. Thereafter the word size of the digital color components is reduced to four bits each, and the run length and color components are coded together as a bit stream of combined run length and color information in sixteen bit digital words. Preferably thereafter adjacent run lengths on each scan line for which the adjacent run lengths have associated color components which vary less than a predetermined amount are concatenated to a digital word size which is larger than the original digital word size of the run lengths. Either or both of the run length portion and the compressed color component code portion of the combinations of run length compressed color codes are preferably statistically encoded by determining the frequency of occurrence of values of either or both portions. A plurality of different codes tables ae provided. The most frequent occurrence of values in a portion is statistically encoded in a first code table by a one bit size digital word. The next three most frequent occurrences are selected and encoded in a second code table by a two bit digital size word, and all of the other values are likewise encoded in at least one additional code table by a digital word size larger than two bits. In the encoding of a table of changes, provision is also made for encoding line-to-line differences, frame-to-frame differences, and determining and encoding movement of distinctive edges of sequences of combinations of run lengths and compressed color codes from frame-to-frame.

According to another aspect, the present invention provides a method of decompressing digital color video data compressed using a compression method, said color video data comprising a first plurality of digitized signals representing combinations of pixel run lengths and corresponding compressed digital color codes for at least a portion of a plurality of scan lines of a first video picture frame, and combinations of pixel run lengths and corresponding compressed digital color codes which have changed for subsequent video picture frames, said compression method using a first look-up table of compressed digital color codes for three corresponding digital color components, said compressed digital color codes representing a selected number of color combinations for the three digital color components, said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame, each said run length comprising the number of sequential pixels having the same compressed digital color codes, said corresponding compressed digital color codes representing selected ones of said compressed digital color codes of said first look-up table, said combinations of run lengths and corresponding compressed digital color codes having a first digital word size, and said corresponding compressed digital color codes having a second digital word size,

the method comprising the steps of:

a) receiving said first plurality of said digitized signals representing run lengths and corresponding compressed digital color codes for at least a portion of a plurality of scan lines of a first picture frame;

b) receiving changes in combinations of run lengths and corresponding compressed digital color codes from said portion of a plurality of scan lines of said first picture frame to a corresponding portion of a plurality of scan lines of a current picture frame;

c) constructing a second plurality of digitized signals defining said current picture frame from said first plurality of digitized signals defining said first picture frame and said changes from said first picture frame to said current picture frame;

d) decoding said corresponding compressed digital color codes of said second plurality of digitized signals according to a second look-up table like said first look-up table to obtain corresponding said three digital color components for each said run length, said corresponding three digital color components having third, fourth, and fifth digital word sizes, respectively;

e) storing said run lengths and said corresponding three digital color components in an array in a buffer memory means;

f) generating a color video display signal from said run lengths and said corresponding three digital color components for said current picture frame by generating the pixels in each said run length from a starting pixel for said run length to an ending pixel for said run length; and

g) repeating steps b) to f) for subsequent video picture frames.

According to a further aspect, the present invention provides a system for decompressing color video data compressed in a compression system, said color video data comprising a first plurality of digitized signals representing combinations of pixel run lengths and corresponding compressed digital color codes for at least a

portion of a plurality of scan lines of a first video picture frame, and combinations of pixel run lengths and corresponding compressed digital color codes which have changed for subsequent video picture frames, said compression system including a first look-up table of compressed digital color codes for three corresponding digital color components, said compressed digital color codes representing a selected number of color combinations for the three digital color components said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame; each said run length comprising the number of sequential pixels having the same compressed digital color codes, said corresponding compressed digital color codes representing selected ones of said compressed digital color codes of said first look-up table, said combinations of run lengths and corresponding compressed digital color component codes having a first digital words size, and said corresponding compressed digital color codes having a second digital word size; said system further comprising:

a) receiving means for receiving said first plurality of said digitized signals representing run lengths and corresponding compressed digital color code for at least a portion of a plurality of scan lines of a first picture frame;
b) means for receiving changes in combinations of run lengths and corresponding compressed digital color codes from said portion of a plurality of scan lines of said first picture frame to a corresponding portion of a plurality of scan lines of a current picture frame;
c) means for constructing a second plurality of said digitized signals defining said current picture frame from said first plurality of digitized signals defining said first picture frame and said changes from said first picture frame to said current picture frame;
d) means for decoding said corresponding compressed digital color codes of said second plurality of digitized signals according to a second look-up table like said first look-up table to obtain corresponding said three digital color components for each said run length, said corresponding three digital color components having third, fourth, and fifth digital word sizes, respectively;
e) means for storing said run lengths and said corresponding three digital color components in an array in buffer memory means; and
f) means for generating a color video display signal from said run length and said corresponding three digital color components for said current picture frame by generating the pixels in each said run length from a starting pixel for said run length to an ending pixel for said run length, and for correspondingly generating color video display signals for all subsequent picture frames.

In a preferred embodiment of the system and the method of the invention for decompressing digital color video data, the run length portions of the three color components for the scan lines of the picture frame are stored in a display buffer memory means which represents a compressed coding of the digital color components for each pixel of the picture frame. The pixels represented in the run length and color components are smoothly mapped from the compressed data in the display buffer memory to a pixel generator from a starting pixel for the run length to the end pixel of the run length, to the end of the portion at each scan line in the picture frame to be mapped. In a preferred embodiment the color portion of the coded digitized signal is converted into three digital color components each having a word size of six bits. In a most preferred embodiment the run length and associated color portions are alternately stored in a first buffer memory until a picture frame in that buffer memory is complete, the pixel generator is switched to display that picture, the run length and associated color components of a next picture frame are stored in a second buffer memory until the picture frame in the second buffer memory is complete, and the storage to the first and second buffer memories is repeated for subsequent picture frames. In the case in which the run length portion of the digitized signal has been concatenated, the method and system of the invention also involve the division of the concatenated run lengths and color component combinations into smaller, unconcatenated run length and digital color component combinations, before storing of the run length and color component information occurs. Each completed picture data point stored in one of the buffer memories is read out and converted by a drawing engine to a smoothly varying group of colors in a display format in synchronism with the video display to repeatedly generate a picture until the second buffer is filled. The drawing engine then switches to the second buffer to draw the next picture while the first buffer is being reloaded with the next picture in the sequence.

Embodiments of the present invention will now be described with reference to the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic diagram of the system and method for compressing color video data in a video communication system in accordance with one embodiment of the present invention;
FIG. 2 is a luminance plot across one scan line in a video picture;
FIG. 3 shows a run length representation of features in a video scan line;
FIG. 4 shows a run length representation of transitions about slope decision points of a video scan line;
FIG. 5 shows a representation of the reconstructed

video scan line for display;

FIG. 6 shows a representation of how the run length data is converted to display data with transitions between runs; and

FIG. 7 is a schematic diagram of a method and system for decompressing color video data in a video communication system in accordance with one embodiment of the present invention;

FIG. 8 shows the system and method for compressing color video data in a video communication system including an additional processor subsystem in accordance with another embodiment of the present invention;

FIG. 9 is a more detailed schematic diagram of a combined I/O control section, processor section, and input construction engine and reconstruction engine;

FIG. 10 is a flow diagram illustrating the compression of digital word sizes of run length and color components;

FIG. 11 is a flow chart illustrating the additional signal processing of color video data;

FIG. 12 shows the system and method for decompressing the color video data in a video communication system including an additional processor subsystem in accordance with a further embodiment of the present invention;

FIG. 13 is a flow diagram of the decoding of the additional data compression processing from Fig. 11;

FIG. 14 is a flow diagram illustrating the decompression of the processed digital words of run length and color components of Fig. 10;

FIG. 15 is an illustration of a three-dimensional color cube.

## DETAILED DESCRIPTION OF THE INVENTION

As is shown in the drawings for purposes of illustration, the invention is embodied in a method and system for compressing color video data in a video telecommunication system having means for producing a color video signal for a plurality of picture frames, with each picture frame comprising a plurality of scan lines composed of a plurality of pixels. For each pixel a luminance function is determined, based upon at least one of the three digital color component signals for at least a substantial portion of the pixels in the scan lines of the picture frame, and one or more decision parameters based upon the difference of the luminance function between pixels a predetermined distance from another pixel on the scan line is determined for at least a substantial portion of the pixels in the scan lines of the picture frame. The value of change of one or more of the decision parameters for each of the pixels is determined, and is compared with corresponding adaptive threshold values to determine which of the pixels in the scan lines are loci for significant changes in the luminance function from pixel to pixel, for determining run lengths of sequentially related pixels.

A digitized color video signal is produced which has three digital color components and a run length portion, the run length portion being of a first digital word size, and the three digital color components being of second, third and fourth digital word sizes, respectively. A histogram is created of up to a predetermined number of the most frequently occurring combinations of the color components in at least a portion of the picture frame. All of the digital color components in the picture frame are encoded to a look up table of digitally compressed color codes of a fifth digital word size smaller than the sum of second, third, and fourth digital word sizes; and the plurality of run lengths are encoded in combination with the digitally compressed color codes. The representation of color with such a limited number of codes allows for a significant reduction in the bit size necessary to represent the color data; and the use of run lengths allows for a further significant reduction in the amount of data required to represent pixels in a picture.

As is shown in the drawings for purposes of illustration, the invention is also embodied in a method and system for decompressing color video data in a video information communication system utilizing a plurality of the digitized signals representing pixel run lengths and digitally compressed color component codes, and a look up table of the digitally compressed color component codes for three corresponding digital color components. The digitally compressed color codes are decoded according to the look up table to form a table of the three digital color components for each of the run lengths, and the run lengths and corresponding color components are stored in an array in a buffer memory to represent run length and color component data for the scan lines in a video picture frame.

The run length and digital color signals are mapped in a pixel generator to a display format representing the pixels in the scan lines of the video picture frame, and the color portion of the digitized signals is converted to three digital color components of appropriate digital word sizes to represent individual points in a picture.

As is illustrated in the drawings, in a preferred implementation of the invention, the video communication system is capable of producing a color video picture using an RGB video camera, generating an analog RGB signal at the normal 60 fields per second, with each field representing half of the picture in an interlaced mode. The signal for the video picture frames generated by the camera 10 is received by an analog to digital converter 12, which converts the red, green and blue (RGB) analog components into digital RGB components, which are each digitized as six bit digital words, forming packets of bits for the RGB components for each pixel of the color video picture of eighteen bits.

The type of the device used to generate the source color video picture is not crucial to the invention, as a camera generating a standard NTSC composite signal which is converted to an RGB digital output would also

be suitable as would a field rate which differs from the standard 60 fields per second. The output of the camera also does not need to be strictly RGB, since other three color component groups may be used to create and transmit color video pictures. For example, the three digital color component signals may be cyan, magenta, and yellow; hue, saturation, and intensity; or even two distinct colors and a third parameter based upon the entire video signal, such as hue, saturation or intensity of an original analog video signal, so that there would be some automatic weighting of the color information generated by the camera.

It is also not essential that the three color components be represented by the same number of bits, since it is known in the television industry that certain ranges of colors are not as easily perceived by the human eye. Such a weighting of information could involve a reduction in the number of bits used for the red component in an RGB scheme, for example, thus permitting transmission of more gradations of other color information that is actually perceptible.

In addition, the source of the color video pictures to be compressed may be a storage means, such as a video disk, a computer file storage media, a video tape, or the like from which the color video information can be processed for introduction into the color video data compression system.

The digitized RGB signal is received by the transition engine portion 14 of the image capture engine 16, which preferably includes integrated circuit means and associated memory means. The first major part of the image capture engine is the transition engine which includes circuitry for determining a luminance function based upon the three color component video signal for each picture element, or pixel, of each scan line in the sequence of video picture frames generated by the analog front end of the system. In the preferred mode, the luminance converter I8 sums the bits from each of the three digital color components for each pixel in the scan lines of the video picture frame to get a luminance (or intensity) value and performs further processing of the data obtained. In the system of the present invention each scan line preferably contains 480 pixels, which matches the resolution of the camera and which provides for better resolution than is typically available in the prior art, in which generally only 256 pixels are utilized per scan line. The luminance of the three color components may be weighted to give greater significance to one color or two colors to provide the luminance function, and may also be based in part upon an original source analog video signal. However, the luminance function is preferably based in part at least upon the sum of the three digital color components. The luminance function derived from the sum of the three six bit color components therefore has a digital word size of eight bits. This luminance function for each pixel is utilized in the input capture engine for evaluating one or more decision parameters based upon the luminance function for determination of those pixels which operate as decision points about which the one or more of the decision parameters are found to vary from a prestored set of threshold values.

The luminance function is an excellent indicator of color changes in the picture, or movements of objects in the picture. In the image capture engine the one or more decision parameters based upon the luminance function may also be used as the basis for determination of differences from line to line, and of distinctive sequences of pixels which define edges of objects which can be determined to be moving from frame to frame. Generally, the luminance, or other combination of color components which comprise the luminance function, undergoes significant changes where there are changes in the characteristics of the picture.

The camera also introduces anomalies or artifacts into the video picture due to noise in the color sampling resolution which ideally should be eliminated to reduce the amount of data to be transmitted since they contribute nothing beneficial to the picture. When the picture is displayed with a new field every 60th of a second, the effect of such anomalies is averaged out by the human eye. Areas having a smooth appearance and little actual detail upon close observation seem to "crawl". This appearance is also known as the "mosquito effect". When a picture is frozen so that only one field or picture frame is being examined, the picture takes on a grainy, speckled appearance. The impact of the noise on the luminance data is in the form of tiny variations in the computed luminance. When the picture is digitized, the digitizing process also converts all of these artifacts to digital representations, even though they do not actually represent picture detail. The processing of luminance in the image capture engine operates to eliminate such meaningless details.

One preferred method eliminating the non-essential details caused by noise in the luminance data is to determine the points of change based at least in part on the luminance function for pixels in the scan lines by comparing differences in one or more decision parameters with corresponding adaptive thresholds. The decision parameters are preferably comprised of differences of the luminance function between pixels, determined between proximate pixels (Diff-1) in a scan line, n plus one n plus two, or even a further distance away, where n represents the position on a scan line of the pixel being examined for changes in luminance; between adjacent first differences (Diff-2), and a cumulative parameter (Cum-diff) which is a sum of the individual difference functions Diff-1, and Diff-2. Each decision parameter has its own corresponding adaptive threshold, having a default value which is subject to modification by the system in response to operator settings. The adaptive threshold preferably has a default value which may be adjusted by the input capture engine responsive to operator or processor selections for resolution. The selecting of the threshold parameters for determining either

the feature or transition decision points is quite subjective. The selection of the parameters determines the number of data points required to define the picture and it also determines the overall perceptual quality of the picture.

Typically for the feature run length determination, two thresholds are used. One is the cumulative change in luminance since the last decision point, Cumdiff. Cumdiff will trigger a decision point if it was greater than 6 and the number of pixels since the last decision point was greater than 5. Another decision parameter is the sum of two adjacent difference values, Diff2 (this is the same as the difference between luminance values that are two pixels apart). If the Diff2 value is computed to be greater than typically 32, the logic will signify that the line is entering an edge, which identifies a decision point, and will stay in the edge characteristic until the Diff2 value falls below 20. When the edge mode is exited, the color of the next pixel is carried all the way back to the pixel where the starting edge determination was made. Also, if Diff2 changes sign, it signifies a new decision point. Changing the values for the cumdiff thresholds greatly affects the quality and data complexity of the picture.

In the slope determination of decision points (apexes), three general conditions are used. An initial slope is determined at the decision point and all measurements are base on that slope. The initial slope, INITS, is determined by computing the following function termed NDIFF2:

$$\text{NDIFF2} = (\text{luminance}_{(i+2)} - \text{luminance}_{(i)})/2$$

INITS is the value of NDIFF2 immediately after the decision point.

CUMDIFF in the slope case is defined the following way:

$$\text{CUMDIFF}_{(i)} = \text{CUMDIFF}_{(i-1)} + \text{NDIFF2}_{(i)}$$

If the absolute value of the CUMDIFF is typically greater than 20 and the number of pixels in the run length is typically greater than 10, then a decision point will be triggered. Similarly, if the absolute value of NDIFF2 is less than or equal to typically 4 and the run length is typically greater than 5, a decision point will be triggered unless the last decision point was also triggered in this manner. The third decision parameter is also based upon NDIFF2:

$$\text{TRIGVAL}_{(i)} = \text{NDIFF2}_{(i)} - \text{INITS}$$

The threshold for TRIGVAL is usually set in the range of 4 to 10 and will trigger a decision point any time the absolute value reaches or exceeds the set value and the run length is at least 2 pixels. Other techniques may be used but these seem to give good quality pictures with an acceptable number of data points.

A graphic representation of a typical plot of luminance across a line of a video picture is shown in Figure 2. The luminance function of the pixels intersected by the scan line 36 is graphically represented by line 38. As is shown in Figure 3, a graph of the decision points based upon comparison of one of the decision parameters with the corresponding adaptive difference threshold in a feature encoding technique, results in stepped line 40, a sequence of horizontal straight lines across the luminance pattern. Each horizontal line represents a separate length of a specific color.

A second approach which may be used to eliminate the non-essential details is a transition or slope encoding technique, which is illustrated in Figure 4. In this technique the rate of change of the differences in the decision parameter between pixels is determined, and the rates of change of these differences are compared with an adaptive, prestored difference rate of change threshold to determine decision points or apex points. These change points or decision points are indicated as X'S on line 39. They indicate the location of the next apex. "Run length" is defined as being the pixel distance between decision points, for both the feature encoding and slope encoding techniques. According to the transition or slope encoding technique, the luminance data results in a line 42 representing a series of apexes or slope decision points, which may be used for controlling the color segments between decision points. A drawing engine can produce a smooth transition of color values for the run length between decision points when the encoded information is to be retrieved. In this technique, for each scan line an initial color is transmitted, followed by as many sequences of run length and color values as are necessary to represent the picture frame content. In either implementation the information is displayed as a series of slopes. For the run length encoded data artifical color slopes are inserted into the display line as shown in Fig. 5. In this case the slopes are generated as a function of the luminance shift between runs and the length of the adjoining runs as shown in Fig. 6.

In the image capture engine of Fig. 1, the decision point detector 26 for determining decision points may alternatively be able to utilize either one of these methods for fixing the decision points in the color of the pixels in the picture, as each method has its respective advantages and disadvantages. The feature coding technique is typically more appropriate for pictures with a complexity of objects with distinctive edges or lines. On the other hand, the slope encoding technique is most suitable for encoding gradual transitions in shading or gradual color changes, but may require additional coding to represent complex pictures with images having many edges and lines. In the preferred implementation of the slope encoding technique, a sequence of thresholds will be compared with decision parameters, and the cumulative parameter (cum-diff) and an adaptive cumulative threshold will also be utilized in determining decision points, to account for those slow, gradual rates of change of luminance which would still result in an accumulated luminance change which is significant enough to merit identification of a decision point.

The three component color codes are also operated

on in the run length processor 28. The transition engine contains a predetermined color map representation of three-component colors, with an n-bit code corresponding to a particular color combination. Here, the colors of the image are matched as closely as possible with the colors in the color map.

The color codes could also be rounded. These truncated or reduced digital color components are then encoded with the run lengths between decision points in the run length processor 28. Although the preferred bit size for the reduced color components is four bits, just as the input digital word size for the color components from the analog front end can be of different sizes to vary the informational content, the reduced digital color components may also be of different sizes. A particular combination of digital word sizes for color components may include a reduced size for the red component, due to the recognition in the industry of the reduced perceptibility of this component.

The feature and slope encoding techniques allow for a variable number of bits to be used to represent an initial picture frame and then changes in subsequent picture frames, in order to encode the minimum number of bits for each picture frame. This is significant a improvement over the prior art which typically analyzes a four by four or three by three block of pixels to compress the information in such a block, which always results in the same number of bits being utilized to represent the informational content in the picture, whether there have been changes outside the segment or not.

The second major portion of the image capture engine is the capture buffer memory (CBM) 29, which receives the encoded run lengths and reduced color components representing some 200 lines of data from the picture frame. Alternatively, if the data rate required becomes too high to send pictures at a desired speed, lesser numbers of scan lines can be stored, such as 150 or 100 lines. The run length and color component information in the capture buffer memory is then transmitted to the video data processor 30, which accesses the run length and color data in the capture buffer memory by an access control 35, and operates as an interface to transform and transmit the video information in a format suitable for transmission by the modem 32, connected to the telephone 34, and which may include means for further compressing the video data, at 33. The video data may also be compared with a previous picture frame stored in an old picture memory 31.

It is possible in a simplification processor 33 of a video data processor 30 to further analyze the difference between color values of pixels after the color codes have been truncated to provide the reduced color component codes, and to concatenate run lengths of such reduced color component codes which vary less than a given threshold value, or to further concatenate run lengths of the reduced color codes based upon variance of one or more of the decision parameters with respect to a corresponding threshold. As the run length code is typically at a maximum of four bits to be compatible with run length and color code combinations of 16 bits, with 16 bit computer buses in the current implementation, concatentation of a sequence of pixels for each run length would be expected to permit coding of up to sixteen pixels per run length. However, in the current implementation the values 0 to 15 are used to represent run lengths of from 2 to 17 pixels, since run lengths of 0 and 1 are not meaningful. Alternatively, longer run lengths may be determined initially as well, as may be compatible with different capacity computer buses, to permit run lengths of greater than 4 bits and run length color code combinations greater than 16 bits.

As mentioned previously, it is expected that the limits of compression required for adequate smoothing of information in a real time sequencing of video pictures in telecommunication would be about 15 frames per second for transmission over conventional telephone lines. It would be possible to use a modem at 1200 bits per second bps), but this would considerably slow the number of frames per second possible in the communication system. Ideally, the system is configured for half duplex mode, and a full duplex mode of configuration would be expected to require two telephone lines. Ideally the modem that is to be used is one which would utilize the largest bandwidth possible, and may be conventional 2400 bps or 9600 bps modem or special modems providing higher rates may be used.

Although the invention has been described in the context of a video telephone conferencing system, the invention may be also be adapted for use in compressing color video data on magnetic media, such as magnetic floppy discs which may be used in storing and communicating such data via computer systems, magnetic hard disks for image storage or short video movie sequences, or on video discs for video disc players which could transmit the information in the form of a full length movie.

With reference to Fig. 7, in the preferred embodiment, a telephone 43 receives a transmitted signal from a transmitter modem over ordinary telephone lines and the receiver modem 44 converts these signals to an electronically digitized format to be receivable by video data processor 46. The video data processor then adapts the digitized signals which represent encoded run length and color information to a format which is acceptable for reception by the drawing engine 62. The drawing engine of the reconstruction engine 48 converts the run length data to slope form and presents it pixel by pixel to the digtal to analog converter for use by the monitor. Alternatively, the video processor interface could be adapted to receive the compressed color video data from a computer system 66 retrieving the information from magnetic media, such as a hard disc or high capacity floppy discs, or from a video disc player for displaying a much greater length series of video picture frames, in a form such as for a video movie. The video data processor preferably includes microprocessor

means and associated memory means (not shown) programmed to carry out various functions. A preferred function is to reconstruct a total picture frame data representation in terms of run length and color codes from an old picture memory 52 of the last picture frame data, and an array of the run lengths and color codes which have changed from the last picture frame. This difference reconstruction function 45 prepares picture frame data for run length reconstruction at 50 and color code reconstruction at 56, utilizing control signals embedded in the run length and color data.

As the run length and color information are received by the video data processor 46 of the reconstruction engine 48, the digitized signals are typically of a digital word size of sixteen bits. The number may vary, depending upon the type of statistical encoding used.

A color code (which may be from 4 to 8 bits in length) is used to select specific colors from a map or pallet so that fewer bits need to be sent. As compressed and encoded from an input construction engine as described earlier, the digital word size of the run length portion actually processed would typically be four bits, and the digital word size of the color code portion would be twelve bits. As mentioned previously, the preferred apportioning of bit sizes of the three color component codes is such that each digital color code component is of a digital word size of four bits. However, only small portions of the picture which have actually changed may be actually encoded, with appropriate control data for skipping run lengths which may not have changed being embedded in the transmitted information. The run length reconstruction or decoder function 50 of the video data processor operates to separate the run length portion from the digitized signal, and the color code reconstruction function 56 of the video data processor, for decoding the color codes, can separate the digital color components from the incoming digitized signals. However, advanced signal processing and compression of the data may also involve the concatenation of run lengths to a digital word size of eight or nine bits, so that the run length decoder function would then also operate to separate the eight or nine bit digital word size into four bit digital word portions. In the event that the run length codes were concatenated to an eight or nine bit digital word size, the color code portion would have also have been subjected to advanced data compression techniques to reduce the three digital color codes each of four bits to a combined color code portion having a digital word size of eight bits. The color reconstruction function 56 would then also operate to convert the eight bit digital color codes to three digital color codes of the four bit digital word size.

From the reconstruction engine run length decoder and color codes sections the run length and color code information is transferred from the video data processor via the access and timing control circuitry 54 in the drawing engine 62 to a drawing engine display buffer memory 57 which ideally comprises dual memory buffers, pingpong A 58 and pingpong B 60. The access and timing control 54, under the direction of the video processor, sends the reconstructed run length and color information for storing in one of the ping pong buffer memory portions until the information for an individual picture frame is complete; that picture is then displayed while the next sequential picture information received by the system is sent and stored in a similar fashion in the second portion of the display buffer memory. Each block of the display buffer memory needs to be of a sufficient capacity to avoid overflow of the memory by the run length and color code information, and it has been found that a random access memory of a capacity of 32K 16 bit digital words is adequate for the picture reconstruction.

The drawing engine 62 includes a pixel generator 61 for converting the run length and color codes stored in the individual pingpong memories to individual points for display on a monitor 64. The access and timing control 54 of the drawing engine is responsible for all display timing and control for the pixel generator. The drawing engine generates a write strobe to write the runs of color information to the series of points to be converted from digital to analog for display.

In the preferred embodiment for pixel generation from feature encoded run length data, each end of a run length of a particular color combination is essentially tapered to provide a smooth color transition from one run length to another. The resulting smoothed reconstructed video line 41 is depicted in Figure 6. When a run length is short, it usually is an indication that the color level is changing rapidly. If the run length is long, it usually indicates the color level is changing slowly. When the change in the luminance function, given by one of the decision parameters, is large, it usually indicates a high probability of an edge in a picture, whereas if the change is small, it is probably an indication of a shading effect. Based upon the run lengths and one or more decision parameters, the pixel generator determines where intermediate decision points should be placed, and interpolates smooth color transitions for each of the RGB color components from one intermediate decision point to the next. The ends of each scan line similarly transition when they contact another color, so that the beginning and ending of a scan line may have a single intermediate decision point adjacent the end, to define a relatively sharp transition from the edge of the picture to the adjacent color. The interpolation is preferably performed linearly, but may also alternatively be shaped to more faithfully depict curved surfaces. If the image is slope encoded, the pixel generates a smooth transition from one apex to the next without injecting an intermediate decision point.

The pixel generator of the drawing engine includes all the necessary functional sections to implement the color interpolation between pairs of points designated by the run lengths, and preferably converts the four bit color components to either six or eight bit digital words,

for six or eight bit precision, in three separate channels, with one for each of the RGB components. Increasing the bit size allows the pixel generator to generate smoother gradations of color transitions between pixels of different colors. For example, although four bit digital word sizes permit up to 4,096 color combinations of red, green and blue components, only up to 16 gradations of any one of the color components would be possible. Increasing the bit size up to 6 allows for up to 64 gradations of any individual component, and up to 262,144 total combinations. An eight bit digital word size permits an even greater range of gradations for an individual component. However, as discussed previously, the full digital word sizes for the color components need not be equal, and may be in fact arranged so as to allow a broader range of colors for one or two of the color components, at the expense of one of the color components which would only require a smaller digital word size to accommodate its perceptibility. The pixel generator therefore dynamically generates a complete digital representation of the pixels of a picture frame to be displayed on a pixel-by-pixel basis, and this information is transmitted on RGB three channels from the pixel generator to the digital to analog converter 63 which converts the video signal to analog form for displaying on the monitor 64.

Referring to Figs. 1 - 9, elements bearing reference numerals 110 to 134 correspond to elements bearing reference numerals 10 to 34. Fig. 8 shows another embodiment with image capture engine 116 having a video processor 130 functioning to further simplify and compress data from the transition engine 114. The output from capture buffer memory 129 is received by the processor subsystem 130 having standard input and output and control 166. The standard I/O 166 typically might include a keyboard, diskette control, a date and time clock, and a monitor output and control. Output from the processor subsystem is typically connected to a modem 132, which is in turn connected to a telephone 134 for transmission of the compressed information over ordinary telephone lines. More than one modem may be used to provide faster image display rates or higher quality color images.

With reference to Fig. 9, the video data processor subsystem 168, which performs the compressing and decompressing functions of the video processor 130 and the video processor 146, to be explained further hereinafter, is most preferably adapted to be connected to both an image capture engine (I.C.E.) and a reconstruction engine (R.C.E.) for use in compressing and decompressing video color data in a two-way communication system. However, where the processor subsystem is being used for compressing the color video information, it should be apparent that the reconstruction engine need not be connected to the same processor subsystem as is connected to the image capture engine. If a video communication system is configured so that the image capture system circuitry is part of a camera, and the reconstruction engine circuitry is part of a display monitor, different processor subsystems 130 and 146 would generally be utilized by the image capture engine and the reconstruction engine.

As is illustrated in Fig. 9, the shared video data processor subsystem receives input from shared capture memory buffer 170 for receiving input from the mage capture engine, and preferably also sends output to a shared display memory buffer 172 which contains section 154, 158 and 160 of the drawing engine, for output to the reconstruction engine. Each of these memory buffers requires sufficient capacity to avoid overflow the encoded information, and it has been found in practice that a memory space of 32K by 16 bits is adequate for these purposes. Memory buffer 170 is also preferably shared for input and output between the image capture engine and the video data processor; and the memory buffer 172 with its dual pingpong memory section is similarly shared for input and output between the reconstruction engine and the video data processor. The processor subsystem includes two microprocessors, which are preferably Motorola 68020 32 bit processors, processor "A" 174, and processor "B" 176. As processor "A" typically performs most of the processing functions of the processor subsystem, it is provided with a private data memory "A" 178 of 512K bytes. Processor "B" is provided with a lesser amount of memory in memory "B" 180 of 256K bytes. Also provided between processor "A" and processor "B" for communication between the processors is a dual port ram 182 of 16K bytes. Dual port RAMS 184 and 186 of 32K bytes are also provided as buffers between processors "A" and "B" and the I/O processor section 166.

The microprocessor "C" 188 for the I/O control section 166 is preferably an Intel 80286 having DRAM refresh and a direct memory access 190 for diskette control and a DRAM 192 of 512K bytes. Input/output ports 194 are designated generally for the standard I/O, which may include disk drives, keyboard, a monitor, and the like.

With reference to Figs. 8, 10 and 11, the operation of the image capture engine and the processor subsystem 130 having simplifying and compressing functions will be described. The run lengths 200 of a sequence of pixels in a scan line having like color values are determined as nine bit digital words which are divided in the image capture engine as four bit digital words 201. The RGB color components 202a, b, c as utilized for determining the luminance functions in section 118 are six bit digital words used for determining decision points for run lengths in the decision point logic 126. These colors are truncated by removing the two least significant bits from each six bit word in the color code truncation circuitry 120 or rounding it to form four bit digital words 204a, b, c. The run length encoder 128 maps a series of run length and RGB color code combinations 205 to the capture buffer memory 129, in preparation for the further processing of the processor subsystem 130. In the pre-

ferred embodiment of this invention, a predetermined default color map 214, in the color code section 120 consisting of a look up table of unique combinations of the three color components such as RGB values and corresponding eight bit codes, maps 256 of the most visually significant color combinations out of a possible 4,096, obtained from the three RGB truncated four bit codes. The color map is preferably alterable by the video data processor subsystem.

The 256 color code combinations to be included in the color map are determined on the following basis. Given that each RGB color component is represented as a four bit code, a range of 16 gradations of each color component is possible. However, in practice the colors at the extremes of each range of gradations rarely appear in images captured by a video camera. Statistical surveys of a wide variety of scenes captured by video cameras reveal a common distribution of colors. To illustrate the distribution, a two-dimensional chart of a range of from 0 to 16 of green downward along a vertical axis, with a range of from 0 to 16 of blue to the right across a horizontal axis yields an oval shaped pattern in the middle, along an axis from 0,0 to 15,15. Adding a third dimension of red yields an sausage-shaped distribution of the most visually significant color combinations from a wide variety of possible scenes and images. A combination selected from an extremity of this sausage-shaped distribution has been found to be virtually indistinguishable from a color combination at a nearby extremity of the three-dimensional color block, and within the sausage-shaped distribution, color combinations proximal to each other are also virtually indistinguishable. By careful selection of 256 representative color combinations from blocks within this sausage-shaped distribution, a color map can thus be constructed of the most visually significant color combinations likely to be encountered. In practice it has been found that an RGB ratio of 4:3:2 produces colors in the skin tone ranges, and this information can be used to balance the color ratio distribution, with the primary factor being subjective appearance.

The color mapping process makes use of the observation that most colors that occur in nature are not very pure. Figure 15 shows a color cube with no color, black, in the front lower left comer and white which is the maximum red, green and blue in the upper right back corner. Green increases to the right from the black, all zeros, origin. Blue increases from the black toward the lower left back corner and red is represented by a number of planes representing constant levels of red. The red increases in the direction of the top of the cube. Thus all of the possible colors may be represented in the cube to a precision which is dependent on the number of bits allocated to each color component. Any specific color may be represented by the coordinates of any point within the cube.

All of the real colors seem to be heavily bunched along a sausage shape which runs from the black corner in an upward arc to the white comer. Since the colors are concentrated with no natural colors occurring in the pure red, green, blue, magenta, cyan or yellow corners, it is possible to reduce the number of color codes from the 4096 possible prepresented by 4 bits each of red, green and blue. The ovals represented by 260, identify the areas which must be reproduced with some precision because the real colors concentrate here.

It is really only necessary to have flesh tones be faithful reproductions with slight off-colors in other areas being quite acceptable since the persons on the receiving end do not know exactly what colors were present in the transmitting end of the system although a correction process may be applied if it is important. The approach for generating the color map has been to define fine gradations in color in the flesh tones with more coarse gradations the further the captured color is away from the central "sausage". The map was empirically derived from examining the color distributions in a large number of pictures and adjusting the map parameters to get acceptable results. The correction process consists of analyzing the actual colors which occur in each of the map areas and correcting the map segment so that it more faithfully represents the detected colors in that scene. The process is quite subjective but seems to work well.

In the processor subsystem, a histogram of the RGB color codes 212 is statistically processed for all of the run length combinations to update the color map 214 to be used as a look up table. Even with the four bit color codes for each of the RGB components, up to 4,096 different color combinations would be theoretically achievable. In practice, it has been found that a group of carefully selected 256 color combinations is quite adequate to serve as apex colors for the drawing engine to construct the image with up to 262,144 colors with six bit color reconstruction of each of the three color components. Alternatively further gradations are possible by reconstructing each of the three color components as eight bit codes. Therefore, the histogram of 256 of the most frequent RGB color combinations may be used to modify the colors encoded as a series of eight bit digital words in the color code look up table or color map 214. Since each color combination in the color map represents a block of ranges of colors, the color frequency histogram may be used to substitute a more frequently occurring color combination within its color block as a representative color combination, for more faithful color reproduction. As these representative colors are within the color block for those colors, the substituted colors are determined by the system are visually significant, and are not merely selected upon frequency of appearance in the picture.

The RGB color information requirement for 12 bits to represent the maximum of 4,096 colors is thus reduced to a table of 256 8 bit digital words to represent the 256 most visually significant colors. Less frequently occurring colors which may be over the limit of 256

colors may also forced to conform to the same coloration as the nearest color code combination in the color map, without significant lessening of the accuracy of the colors in the picture frame to be transmitted. Once the color codes are in the form of eight bit digital words 206 which may be combined with the four bit run length portion 200, the four bit run length code, which actually represents a run length of from 2 to 17 pixels in the preferred implementation of the encoding of run lengths, can be statistically processed to provide a varying length digital word 208 to be assembled in the eventual fully processed run length color code combination 210. The run length codes may vary from one bit for most frequent lengths up to 8 or 10 for rarely occurring lengths. Thus, the run length may represent from 2 to 257 pixels, which would be theoretically adequate to represent an entire scan line of 512 pixels in two run length color code combinations. Thus, the four bit run lengths are concatenated where possible at 216 finally before encoding the run length and color code combinations at 218. In order to accommodate the encoding of the eight bit RGB color components in the run length combinations, it is also necessary to construct and encode the color code look up table 214 as a table of 256 individual four bit color codes for each of the RGB components, which would be transmitted with the color code run length combinations to enable a receiver or translator of the picture information to decode compressed color information.

More advanced processing and compression of the run length color code combinations may also occur in the advanced processing section 220. Similar to the pixel to pixel differencing and comparison for determination of decision points in the input construction engine, adjacent scan lines may be compared to formulate a table of scan lines which do not differ from the previous scan line in the direction of scanning, so that the lines or portions of lines may be merely duplicated. Thus, this would allow further compression of the run length and color code combinations 210 as a differences table 222. Another technique termed subframe processing may be used to reduce the amount of data which must be sent to update a new picture on the receiving section of a system. This subframe processing technique samples every nth line and continues processing only with those lines for any one image. Distinctive segments of run length combinations which appear to form an edge may be detected in an edge detector 224 to monitor the displacement of such segments from frame-to-frame by movement analysis 226, which preferably could track the movement of such scan line segments in groups of scan line segments according to any horizontal shifting, shrinking, growing, or vertical displacement of such segments, or virtually any combination of such movements. A further level of compression involves the frame-to-frame differencing by comparison of the run length and color codes combination information from the last picture frame with the current picture frame, and encoding of a skip code to identify those portions which have not changed, so that only the run length and color code combinations which have changed are encoded at 238.

Finally, the processor subsystem also preferably encodes the run length and color code combinations to be transmitted from the processor subsystem by determining a histogram of the occurrence of run length and color code combinations. The preferred form of statistical encoding at this stage is similar to Huffman coding, and involves the assignment of the most frequently occurring combination to a table of one bit digital words, at 230. This table is to be utilized at the receiving end of the system by referring to one or the other of the bit states of the one bit digital word to fill in this most frequently occurring run length combination in a corresponding run length color code table. For example, if the table indicates a binary one, the receiving table would be filled in with the run length color code combination, and would otherwise be left with a marker of zero indicating that the spot in the table was to be filled in later. The next three most occurring combination are then represented as a two bit length digital word, with one of the binary bit states again indicating that the receiving table location was to be filled in later, and the next three most frequently occurring combinations are filled in their respective locations in the corresponding receiving table. A three bit digital word table can then be constructed in a similar fashion to designate the next seven most frequently occurring values, with one of the binary bit states representing values to be filled in later, and so on, with a final digital word size of eight bits used to represent the remaining color code combinations. This process may be applied to other groupings than the 1, 2, 3, n bit grouping sequences described above. Most preferably, this statistical encoding of the compressed run length color code information is performed for at least the color codes, individually, with the run length portions then being encoded and received as a separate table of eight bit digital words, but it is also possible to separately statistically encode the eight bit run length portions in a similar fashion and transmit a separate statistically encoded table for the run length components of the run length-color code combinations. Other similar statistical encoding approaches may also be appropriate as an alternative.

Referring to Fig. 12, in which elements 143 to 166 are essentially identical to those previously described which bear reference numerals 43 to 66, in the preferred mode of the invention the telephone 143 receives the audio digitized signals from the transmitter modem over ordinary telephone lines, which is in turn received by the receiving modem 144, and the video data processor 146, which prepares the digitized video signal in a form and format adapted to the receivable by the drawing engine 162. The video data processor 146 is connected to the input/output and control section 166. The architecture of the processor subsystem is generally as has been described and illustrated in Fig. 9. The digitized signal representing combinations of a plurality of run

lengths of a first digital word size and digitally compressed color component code of at least a portion of a plurality of scan lines of a video picture frame, and a look up table of the digitally compressed color component codes, are subjected to decoding of the color component codes according to the look up table to form a table of the three digital color component in the memory of the processor color reconstruction at 156, and the run length and color components are sent to the display buffer memory 157, which includes the dual memory space 172, the access timing and control 154 and the two pingpong buffers 158 and 160.

As with the signal processed by the reconstruction engine discussed with reference to Fig. 7, the run length decoder 150 receives the decompressed run length information, and the color component information, for decoding of the run length information, is reconstructed in 156. The color and length information are compared with the prior picture 152 for mapping at 150 and 156 to the display buffer memory 157 which comprises the pingpong memory "A" 158 and the pingpong memory "B" 160. The pixel generator 161 is slaved by the display buffer memory 157 from the pingpong memories alternately, to reconstruct the scan lines of the transmitted picture pixel by pixel, which is then converted from digital form to analog form in the digital to analog converter 163, for display on the monitor 164.

With reference to Figs. 13 and 14, in the preferred embodiment of the processor subsystem 146 of the invention, prior to the difference reconstruction at 145 occurring in video data processor, the statistical coding is decoded at 232 and possibly also at 234 by formation of a table in the memory of the processor subsystem of the run length and associate color codes, to be filled in at 156 according to the look up table, as explained previously. In the advanced difference reconstruction operations 145, the frame-to-frame differences and line-to-line differences tables are decoded at 234 for decoding the differences from frame-to-frame at 236 or changes from line-to-line at 238, with reference to the old picture memory 152. Also in the difference reconstruction operation, the tables representing the edges and movement are decoded at 240 and 242, with the picture information between the edges being constructed by interpolation. The division at 246 of run lengths of the concatenated digital word size to run lengths of a four bit digital word size occurs in the run length reconstruction operation 150. The decoding of the compressed color codes in the color reconstruction operation 156, according to the look up table, occurs at 248, allowing the four bit, six bit, or eight bit color component codes to be assigned to the run lengths, for storage at 250 in the display buffer memory 157.

Thus, referring to Fig. 14, in the statistical decoding of the fully compressed digitized signal, the tables reconstructed are of the four bit digital word size run length 256, and the eight bit digital word size RGB compressed color code 254. The run length-color decoder treats the run length portion separately to provide the four bit digital word size run length portions 256; and the eight bit digital word size RGB compressed color codes are decoded to provide the individual four bit digital word size RGB components 256a, 256b, and 256c. The four bit run length and four bit digital RGB color codes are mapped to the buffer memory, for processing by the reconstruction engine, and transmission to the pixel generator, where the four bit digital color components are expressed as an interpolation of six bit digital RGB components 258a, 258b, and 258c, for individual pixels between start and stop points representing the run length.

Although the invention has been described in the context of a video telephone conferencing system, the invention may be also be adapted for use in decompressing color video data from magnetic media, such as hard disks or three and a half inch high capacity magnetic floppy discs which may be used in storing and communicating such data via computer systems, or from video discs for video disc players which could transmit the information in the form of a video movie.

In the foregoing description, it has been demonstrated that the method and system of embodiments of the invention permit the encoding, transmission, and retrieval of color video data by the truncation of least significant information from the color component codes, and the statistical encoding of the most visually significant color code combinations. The embodiments also provide for further processing of the color video data by further compression of the data by encoding concatenated run lengths, line-to-line differences, movement of segments of picture frames and portions of picture frames which have changed to reduce the amount of information to be encoded to the minimum amount. The embodiments further provide for additional compression of the color video data by a form of statistical encoding, which permits a further reduction of the amount of information which must be transmitted by the system.

## Claims

1. A method of compressing digital color video data comprising a color video signal for a plurality of video picture frames, with each picture frame comprising a plurality of scan lines composed of a plurality of pixels, and each pixel in said picture frame comprising three digital color components, said method comprising the steps of:

   a) determining a luminance value for each pixel as a function of at least one of said three digital color components;
   b) evaluating at least one decision parameter for each pixel of at least a substantial portion of each of a plurality of scan lines of a current picture frame, by determining the difference between the luminance value of each pixel and

the luminance value of at least one other pixel of the same scan line;
c) comparing said at least one decision parameter for each pixel with a corresponding adjustable threshold value to determine which pixels have a luminance value which is changed from the luminance value of said at least one other pixel by more than a predetermined amount, each of said pixels having such a changed luminance value being either a starting pixel or an ending pixel for a run length of sequentially related pixels in a said scan line, said run length being represented as a first part of a digital signal, said first part having a first digital word size, each pixel in each run length being defined to have the same three digital color components, said three digital color components being second, third and fourth parts of said digital signal having second, third, and fourth digital word sizes, respectively;
d) encoding said three digital color components of each run length in said picture frame according to a look-up table of compressed digital color codes of a fifth digital word size smaller than the sum of said second, third and fourth digital word sizes; said compressed digital color codes representing a selected number of color combinations, said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame, said encoding step comprising the step of selecting the compressed digital color codes representing the best match between said digital color components of each run length and said selected number of color combinations;
e) encoding the three digital color components of each set of said sequentially related pixels as a combination of the run length and associated said compressed digital color codes;
f) comparing said run lengths and said compressed digital color codes of said current picture frame with the run lengths and compressed digital color codes of a previous picture frame to determine changes from said previous picture frame to said current picture frame; and
g) encoding said changes from said previous picture frame to said current picture frame for at least a portion of said picture frames, whereby once an initial picture frame is encoded, only changes in subsequent picture frames are encoded.

2. The method of Claim 1, wherein said step of comparing said at least one decision parameter with a corresponding adjustable threshold value comprises the steps of determining the rates of change of the differences in said at least one decision parameter between pixels of said substantial portion of said scan line for each of said pixels, and comparing each said rate of change with a corresponding adjustable rate of change threshold, to determine which of said pixels have a predetermined change in luminance and comprise said starting and ending pixels.

3. The method of Claim 1, wherein said step of comparing said at least one decision parameter for each pixel with a corresponding adjustable threshold value comprises the step of comparing the values of a plurality of said decision parameters with a corresponding plurality of thresholds to determine which pixels have a predetermined change in luminance and comprise said starting pixels and said ending pixels.

4. The method of Claim 1, further including, after step e), the steps of comparing pixels of adjacent scan lines, and formulating a table of run lengths and compressed digital color codes representing scan lines which do not differ from one scan line to the next adjacent scan line in a picture frame in the scanning direction, for each picture frame.

5. The method of Claim 1, wherein said step of comparing said at least one decision parameter with a corresponding adjustable threshold value further comprises the step of detecting edges of an image as successive combinations of said run lengths and compressed digital color codes in at least one scan line for each picture frame, said successive combinations being related according to a predefined criterion that demarcates the successive combinations as an edge, and said step of encoding said changes from said previous picture frame to said current picture frame further comprises storing the changes in said successive combinations in a table so as to sequentially represent a movement of said edge from one frame to another frame.

6. A system for compressing digital color video data comprising a color video signal for a plurality of video picture frames, with each picture frame comprising a plurality of scan lines composed of a plurality of pixels, and each pixel in said picture frame comprising three digital color components, said system comprising:

a) means (18;118) for determining a luminance value for each pixel using at least one of said three digital color components;
b) means (26: 126) for evaluating at least one decision parameter for each pixel of at least a substantial portion of each of a plurality of scan lines of a current picture frame, by determining the difference between the luminance value of each pixel and the luminance value of at least

one other pixel of the same scan line;
c) means (29; 129) for comparing said at least one decision parameter for each pixel with a corresponding adjustable threshold value to determine which pixels have a luminance value which is changed from the luminance value of said at least one other pixel by more than a predetermined amount, each of said pixels having such a changed luminance value being either a starting pixel or an ending pixel for a run length of sequentially related pixels in a said scan line, said run length being represented as a first part of a digital signal, said first part having a first digital word size, each pixel in a said run length being defined to have the same three digital color components, said three digital color components being second, third and fourth parts of said digital signal having second, third and fourth digital word sizes, respectively;
d) means (212; 214) for encoding said three digital color components of each run length in said picture frame according to a look-up table (120) of compressed digital color codes of a fifth digital word size smaller than the sum of said second, third and fourth digital word sizes; said compressed digital color codes representing a selected number of color combinations, said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame, said encoding means (212,; 214) comprising means for selecting the compressed digital color codes representing the best match between said digital color components of each run length and said selected number of color combinations;
e) means (218) for encoding the three digital color components of each set of said sequentially related pixels as a combination of the run length and associated said compressed digital color codes;
f) means (222) for comparing said run lengths and said compressed digital color codes of said current picture frame with the run lengths and compressed digital color codes of a previous picture frame to determine changes from said previous picture frame to said current picture frame; and
g) means (228) for encoding said changes from said previous picture frame to said current picture frame for at least a portion of said picture frames, whereby once an initial picture frame is encoded, only changes in subsequent picture frames are encoded.

7. The system of Claim 6, wherein said means (222) for comparing said at least one decision parameter with a corresponding adjustable threshold value comprises means for determining the rates of change of the differences in said at least one decision parameter between pixels of said substantial portion of said scan line for each of said pixels, and means for comparing each said rate of change with a corresponding rate of change threshold to determine which of said pixels have a predetermined change in luminance and comprise said starting pixels and said ending pixels.

8. The system of Claim 6, wherein said means (222) for comparing said at least one decision parameter for each pixel with a corresponding adjustable threshold comprises means for comparing the values of a plurality of said decision parameters with a corresponding plurality of thresholds to determine which pixels have a predetermined change in luminance and represent said starting pixels and said ending pixels.

9. The system of Claim 6, further including means (228) for receiving the output of said means (218) for encoding the three digital color components and for comparing pixels of adjacent scan lines, and means for formulating a table of run lengths and compressed digital color codes representing scan lines which do not differ from one scan line to the next adjacent scan line in a picture frame in the scanning direction, for each picture frame.

10. The system of Claim 6, wherein said means (29, 129) for comparing said at least one decision parameter with a corresponding adjustable threshold value includes means for detecting edges of an image as successive combinations of said run lengths and compressed digital color codes in at least one scan line for each picture frame, said sucessive combinations being related according to a predetermined criterion that demarcates the successive combinations as an edge, and said means (228) for encoding said changes from said previous picture frame to said current picture frame includes means for storing the changes in said successive combinations as a table so as to sequentially represent a movement of said edge from one frame to another frame.

11. A method of decompressing digital color video data compressed using a compression method, said video data comprising a first plurality of digitized signals representing combinations of pixel run lengths and corresponding compressed digital color codes for at least a portion of a plurality of scan lines of a first video picture frame, and combinations of pixel run lengths and corresponding compressed digital color codes which have changed for subsequent video picture frames, said compression method using a first look-up table (120) of compressed digital color codes for three corresponding digital color

components, said compressed digital color codes representing a selected number of color combinations for the three digital color components, said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame, each said run length comprising the number of sequential pixels having the same compressed digital color codes, said corresponding compressed digital color codes representing selected ones of said compressed digital color codes of said first look-up table (120), said combinations of run lengths and corresponding compressed digital color codes having a first digital word size, and said corresponding compressed digital color codes having a second digital word size, the method comprising the steps of:

a) receiving said first plurality of said digitized signals representing run lengths and corresponding compressed digital color codes for at least a portion of a plurality of scan lines of a first picture frame;
b) receiving changes in combinations of run lengths and corresponding compressed digital color codes from said portion of a plurality of scan lines of said first picture frame to a corresponding portion of a plurality of scan lines of a current picture frame;
c) constructing a second plurality of said digitized signals defining said current picture frame from said first plurality of digitized signals defining said first picture frame and said changes from said first picture frame to said current picture frame;
d) decoding said corresponding compressed digital color codes of said second plurality of digitized signals according to a second look-up table (248) like said first look-up table (120) to obtain corresponding said three digital color components for each said run length, said corresponding three digital color components having third, fourth, and fifth digital word sizes, respectively;
e) storing said run lengths and said corresponding three digital color components in an array in a buffer memory means (58, 60, 158, 160);
f) generating a color video display signal from said run lengths and said corresponding three digital color components for said current picture frame by generating the pixels in each said run length from a starting pixel for said run length to an ending pixel for said run length; and
g) repeating steps b) to f) for subsequent video picture frames.

12. The method of Claim 11, wherein the step of generating a color video display signal from said run lengths and said corresponding three digital color components comprises the steps of generating said starting pixel for each run length using said corresponding three digital color components, and generating the remaining pixels in said run length by interpolating a smooth color transition to the starting pixel of the next run length.

13. The method of Claim 11, wherein said step of storing said run lengths and said corresponding three digital color components in an array in a buffer memory means (58, 60, 158, 160) comprises the steps of storing said run lengths and said corresponding three digital color components in a first buffer memory (58, 158) until a first set of said data for a first picture frame is complete; storing said run lengths and said corresponding three digital color components of a next set of picture frame data to a second buffer memory (60, 160) until said next picture frame is complete; and repeating said steps of storing in said first and second buffer memories (58, 60, 158, 160) for subsequent picture frame data.

14. The method of Claim 11, wherein, in said compression method, said combinations of run lengths and corresponding compressed digital color codes of said digitized signals have been formulated in a table representing scan lines which do not differ from one scan line to the next adjacent scan line in a picture frame in the scanning direction, for each picture frame; the method further including the steps of decoding said table of run lengths and corresponding compressed digital color codes, and generating run lengths and corresponding compressed color codes for said adjacent scan lines.

15. The method of Claim 11, wherein, in said compression method, distinctive edges of an image that have moved, determined as successive combinations of said run lengths and corresponding compressed digital color codes in at least one scan line, have been included in a table for each picture frame representing changes in said successive combinations so as to represent movement of said edges from one picture frame to another picture frame, the method further including the step of storing said changes in said successive combinations in an array.

16. A system for decompressing color video data compressed in a compression system, said video data comprising a first plurality of digitized signals representing combinations of pixel run lengths and corresponding compressed digital color codes for at least a portion of a plurality of scan lines of a first video picture frame, and combinations of pixel run lengths and corresponding compressed digital color codes which have changed for subsequent video picture frames, said compression system in-

cluding a first look-up table (120) of compressed digital color codes for three corresponding digital color components, said compressed digital color codes representing a selected number of color combinations for the three digital color components, said selected number being predetermined as the most visually significant color combinations likely to occur in said picture frame; each said run length comprising the number of sequential pixels having the same compressed digital color codes, said corresponding compressed digital color codes representing selected ones of said compressed digital color codes of said first look-up table, said combinations of run lengths and corresponding compressed digital color component codes having a first digital word size, and said corresponding compressed digital color codes having a second digital word size; said system further comprising:

a) receiving means (52) for receiving said first plurality of said digitized signals representing run lengths and corresponding compressed digital color codes for at least a portion of a plurality of scan lines of a first picture frame;
b) means (236) for receiving changes in combinations of run lengths and corresponding compressed digital color codes from said portion of a plurality of scan lines of said first picture frame to a corresponding portion of a plurality of scan lines of a a current picture frame;
c) means (45, 145) for constructing a second plurality of said digitized signals defining said current picture frame from said first plurality of digitized signals defining said first picture frame and said changes from said first picture frame to said current picture frame;
d) means (56, 248) for decoding said corresponding compressed digital color codes of said second plurality of digitized signals according to a second look-up table (248) like said first look-up table (120) to obtain corresponding said three digital color components for each said run length, said corresponding three digital color components having third, fourth, and fifth digital word sizes, respectively;
e) means (54, 154, 250) for storing said run lengths and said corresponding three digital color components in an array in buffer memory means (58, 60, 158, 160); and
f) means (61, 161) for generating a color video display signal from said run length and said corresponding three digital color components for said current picture frame by generating the pixels in each said run length from a starting pixel for said run length to an ending pixel for said run length, and for correspondingly generating color video display signals for all subsequent picture frames.

**17.** The system of Claim 16, wherein said means (61, 161) for generating a color video display signal from said run length and said corresponding three digital color components comprises means for generating said starting pixel for each run length using said corresponding three digital color components, and means for generating the remaining pixels in said run length by interpolating a smooth color transition to the starting pixel of the next run length.

**18.** The system of Claim 16, wherein said means (54, 154, 250) for storing said run lengths and said corresponding three digital color components in an array in a buffer memory means (58, 60, 158, 160) comprises means for storing said run lengths and said corresponding three digital color components in a first buffer memory (58, 158) until a first set of said data for a first picture frame is complete, for storing said run lengths and said corresponding three digital color components of a next set of picture frame data to a second buffer memory (60, 160) until said next picture frame is complete, and for repeating said steps of storing in said first and second buffer memories (18, 60, 158, 160) for subsequent picture frame data.

**19.** The system of Claim 16, wherein, in the compression system, said combinations of run lengths and corresponding compressed digital color codes of said digitized signals have been formulated in a table representing scan lines which do not differ from one scan line to the next adjacent scan line in a picture frame in the scanning direction, for each picture frame; the system further including means (24) for decoding said table of run lengths and corresponding compressed digital color codes, and means for generating run lengths and corresponding compressed color codes for said adjacent scan lines.

**20.** The system of Claim 16, wherein, in the compression system, distinctive edges of an image that have moved, determined as successive combinations of said run lengths and corresponding compressed digital color codes in at least one scan line, have been included in a table for each picture frame representing changes in said successive combinations so as to represent movement of said edges from one picture frame to another picture frame, the system further including means (242) for storing said changes in said successive combinations in an array.

**Patentansprüche**

**1.** Verfahren zum Komprimieren von digitalen Farbvideodaten, welche ein Farbvideosignal für eine Mehrzahl von Videobildern umfassen, wobei jedes

Bild eine Mehrzahl von Abtastzeilen umfaßt, die aus einer Mehrzahl von Pixeln aufgebaut sind, und wobei jedes Pixel in dem Bild drei digitale Farbkomponenten umfaßt, wobei das Verfahren die Schritte umfaßt:

a) Ermitteln eines Luminanzwerts für jedes Pixel als Funktion wenigstens einer der drei digitalen Farbkomponenten,

b) Auswerten mindestens eines Entscheidungsparameters für jedes Pixel von jeweils zumindest einem wesentlichen Teil einer Mehrzahl von Abtastzeilen eines momentanen Bilds, und zwar dadurch, daß die Differenz zwischen dem Luminanzwert jedes Pixels und dem Luminanzwert wenigstens eines anderen Pixels derselben Abtastzeile ermittelt wird,

c) Vergleichen des mindestens einen Entscheidungsparameters für jedes Pixel mit einem entsprechenden einstellbaren Schwellenwert, um festzustellen, welche Pixel einen Luminanzwert besitzen, der sich gegenüber dem Luminanzwert des wenigstens einen anderen Pixels um mehr als einen vorbestimmten Betrag geändert hat, wobei jedes der Pixel, das einen solchen geänderten Luminanzwert besitzt, entweder ein Startpixel oder ein Endpixel für eine Lauflänge von sequentiell zusammenhängenden Pixeln in einer Abtastzeile ist, wobei diese Lauflänge als erster Teil eines digitalen Signals dargestellt wird, wobei dieser erste Teil eine erste Digitalwortgröße besitzt, wobei jedes Pixel in jeder Lauflänge mit den selben drei digitalen Farbkomponenten definiert wird, wobei die drei digitalen Farbkomponenten ein zweiter, dritter und vierter Teil des digitalen Signals mit einer zweiten, dritten bzw. vierten Digitalwortgröße sind,

d) Codieren der drei digitalen Farbkomponenten jeder Lauflänge in dem Bild nach Maßgabe einer Nachschlagetabelle von komprimierten digitalen Farbcodes, welche eine fünfte Digitalwortgröße besitzen, die kleiner als die Summe der zweiten, dritten und vierten Digitalwortgröße ist, wobei die komprimierten digitalen Farbcodes eine ausgewählte Zahl von Farbkombinationen darstellen, wobei diese ausgewählte Zahl im voraus nach den visuell bedeutsamsten Farbkombinationen, die voraussichtlich in dem Bild vorkommen, festgelegt wird, wobei der Codierungsschritt den Schritt des Auswählens derjenigen komprimierten digitalen Farbcodes umfaßt, welche die beste Übereinstimmung zwischen den digitalen Farbkomponenten jeder Lauflänge und der ausgewählten Zahl von Farbkombinationen darstellen, e) Codieren der drei digitalen Farbkomponenten jeder Gruppe von sequentiell zusammenhängenden Pixeln als Kombination der Lauflänge und der zugeordneten komprimierten digitalen Farbcodes,

f) Vergleichen der Lauflängen und der komprimierten digitalen Farbcodes des momentanen Bilds mit den Lauflängen und komprimierten digitalen Farbcodes eines vorherigen Bilds, um Veränderungen vom vorherigen Bild zum momentanen Bild zu ermitteln, und

g) Codieren dieser Veränderungen von dem vorherigen Bild zum momentanen Bild für zumindest einen Teil der Bilder, wodurch lediglich Veränderungen in nachfolgenden Bildern codiert werden, sobald ein Anfangsbild codiert ist.

2. Verfahren nach Anspruch 1, bei dem der Schritt des Vergleichens des mindestens einen Entscheidungsparameters mit einem entsprechenden einstellbaren Schwellenwert die Schritte umfaßt: Ermitteln der Änderungsraten der Differenzen des mindestens einen Entscheidungsparameters zwischen Pixeln des wesentlichen Teils der Abtastzeile für jedes der Pixel und Vergleichen jeder Änderungsrate mit einer entsprechenden einstellbaren Änderungsratenschwelle, um festzustellen, welche der Pixel eine vorbestimmte Luminanzänderung aufweisen und die Start- und Endpixel umfassen.

3. Verfahren nach Anspruch 1, bei dem der Schritt des Vergleichens des mindestens einen Entscheidungsparameters für jedes Pixel mit einem entsprechenden einstellbaren Schwellenwert den Schritt umfaßt: Vergleichen der Werte einer Mehrzahl der Entscheidungsparameter mit einer entsprechenden Mehrzahl von Schwellen, um festzustellen, welche Pixel eine vorbestimmte Luminanzänderung aufweisen und die Startpixel und die Endpixel umfassen.

4. Verfahren nach Anspruch 1, ferner umfassend nach Schritt e) die Schritte: Vergleichen von Pixeln benachbarter Abtastzeilen und Aufstellen einer Tabelle von Lauflängen und komprimierten digitalen Farbcodes, welche solche Abtastzeilen darstellt, die sich von einer Abtastzeile in einem Bild zu der in Abtastrichtung nächsten benachbarten Abtastzeile nicht unterscheiden, und zwar für jedes Bild.

5. Verfahren nach Anspruch 1, bei dem der Schritt des Vergleichens des mindestens einen Entscheidungsparameters mit einem entsprechenden einstellbaren Schwellenwert ferner der Schritt umfaßt: Erfassen von Kanten einer bildhaften Darstellung als aufeinanderfolgende Kombinationen der Lauflängen und komprimierten digitalen Farbcodes in wenigstens einer Abtastzeile für jedes Bild, wobei die aufeinanderfolgenden Kombinationen nach Maßgabe eines im voraus definierten Kriteriums in

Zusammenhang stehen, welches die aufeinanderfolgenden Kombinationen als eine Kante demarkiert, und bei dem der Schritt des Codierens der Veränderungen von dem vorherigen Bild zu dem momentanen Bild ferner das Speichern der Veränderungen in den aufeinanderfolgenden Kombinationen in einer Tabelle umfaßt, um so eine Bewegung der Kante von einem Bild zu einem anderen Bild sequentiell darzustellen.

6. System zum Komprimieren von digitalen Farbvideodaten, welche ein Farbvideosignal für eine Mehrzahl von Videobildern umfassen, wobei jedes Bild eine Mehrzahl von Abtastzeilen umfaßt, die aus einer Mehrzahl von Pixeln aufgebaut sind, und wobei jedes Pixel in dem Bild drei digitale Farbkomponenten umfaßt, wobei das System umfaßt:

a) Mittel (18; 118) zum Ermitteln eines Luminanzwerts für jedes Pixel unter Verwendung wenigstens einer der drei digitalen Farbkomponenten,
b) Mittel (26; 126) zum Auswerten mindestens eines Entscheidungsparameters für jedes Pixel von jeweils zumindest einem wesentlichen Teil einer Mehrzahl von Abtastzeilen eines momentanen Bilds, und zwar dadurch, daß die Differenz zwischen dem Luminanzwert jedes Pixels und dem Luminanzwert wenigstens eines anderen Pixels derselben Abtastzeile ermittelt wird,
c) Mittel (29; 129) zum Vergleichen des mindestens einen Entscheidungsparameters für jedes Pixel mit einem entsprechenden einstellbaren Schwellenwert, um festzustellen, welche Pixel einen Luminanzwert besitzen, der sich gegenüber dem Luminanzwert des wenigstens einen anderen Pixels um mehr als einen vorbestimmten Betrag geändert hat, wobei jedes der Pixel, das einen solchen geänderten Luminanzwert besitzt, entweder ein Startpixel oder ein Endpixel für eine Lauflänge von sequentiell zusammenhängenden Pixeln in einer Abtastzeile ist, wobei diese Lauflänge als erster Teil eines digitalen Signals dargestellt wird, wobei dieser erste Teil eine erste Digitalwortgröße besitzt, wobei jedes Pixel in einer Lauflänge mit den selben drei digitalen Farbkomponenten definiert wird, wobei die drei digitalen Farbkomponenten ein zweiter, dritter und vierter Teil des digitalen Signals mit einer zweiten, dritten bzw. vierten Digitalwortgröße sind,
d) Mittel (212; 214) zum Codieren der drei digitalen Farbkomponenten jeder Lauflänge in dem Bild nach Maßgabe einer Nachschlagetabelle (120) von komprimierten digitalen Farbcodes, welche eine fünfte Digitalwortgröße besitzen, die kleiner als die Summe der zweiten, dritten und vierten Digitalwortgröße ist, wobei die komprimierten digitalen Farbcodes eine ausgewählte Zahl von Farbkombinationen darstellen, wobei diese ausgewählte Zahl im voraus nach den visuell bedeutsamsten Farbkombinationen, die voraussichtlich in dem Bild vorkommen, festgelegt wird, wobei die Codierungsmittel (212; 214) Mittel zum Auswählen derjenigen komprimierten digitalen Farbcodes umfassen, welche die beste Übereinstimmung zwischen den digitalen Farbkomponenten jeder Lauflänge und der ausgewählten Zahl von Farbkombinationen darstellen,
e) Mittel (218) zum Codieren der drei digitalen Farbkomponenten jeder Gruppe von sequentiell zusammenhängenden Pixeln als Kombination der Lauflänge und der zugeordneten komprimierten digitalen Farbcodes,
f) Mittel (222) zum Vergleichen der Lauflängen und der komprimierten digitalen Farbcodes des momentanen Bilds mit den Lauflängen und komprimierten digitalen Farbcodes eines vorherigen Bilds, um Veränderungen von dem vorherigen Bild zu dem momentanen Bild zu ermitteln, und
g) Mittel (228) zum Codieren der Veränderungen von dem vorherigen Bild zu dem momemtanen Bild für wenigstens einen Teil der Bilder, wodurch lediglich Veränderungen in nachfolgenden Bildern codiert werden, sobald ein Anfangsbild codiert ist.

7. System nach Anspruch 6, bei dem die Mittel (222) zum Vergleichen des mindestens einen Entscheidungsparameters mit einem entsprechenden einstellbaren Schwellenwert Mittel zum Ermitteln der Änderungsraten der Differenzen des mindestens einen Entscheidungsparameters zwischen Pixeln des wesentlichen Teils der Abtastzeile für jedes der Pixel umfassen sowie Mittel zum Vergleichen jeder Änderungsrate mit einer entsprechenden Änderungsratenschwelle umfassen, um festzustellen, welche der Pixel eine vorbestimmte Luminanzänderung aufweisen und die Startpixel und die Endpixel umfassen.

8. System nach Anspruch 6, bei dem die Mittel (222) zum Vergleichen des mindestens einen Entscheidungsparameters für jedes Pixel mit einer entsprechenden einstellbaren Schwelle Mittel zum Vergleichen der Werte einer Mehrzahl der Entscheidungsparameter mit einer entsprechenden Mehrzahl von Schwellen umfassen, um festzustellen, welche Pixel eine vorbestimmte Luminanzänderung aufweisen und die Startpixel und die Endpixel darstellen.

9. System nach Anspruch 6, ferner umfassend Mittel (228) zum Empfangen der Ausgabe der Mittel (218)

zum Codieren der drei digitalen Farbkomponenten und zum Vergleichen von Pixeln benachbarter Abtastzeilen sowie Mittel zum Aufstellen einer Tabelle von Lauflängen und komprimierten digitalen Farbcodes, welche solche Abtastzeilen darstellt, die sich von einer Abtastzeile in einem Bild zu der in Abtastrichtung nächsten benachbarten Abtastzeile nicht unterscheiden, und zwar für jedes Bild.

10. System nach Anspruch 6, bei dem die Mittel (29, 129) zum Vergleichen des mindestens einen Entscheidungsparameters mit einem entsprechenden einstellbaren Schwellenwert Mittel zum Erfassen von Kanten einer bildhaften Darstellung als aufeinanderfolgende Kombinationen der Lauflängen und komprimierten digitalen Farbcodes in wenigstens einer Abtastzeile für jedes Bild umfassen, wobei die aufeinanderfolgenden Kombinationen nach Maßgabe eines vorbestimmten Kriteriums in Zusammenhang stehen, welches die aufeinanderfolgenden Kombinationen als eine Kante demarkiert, und wobei die Mittel (228) zum Codieren der Veränderungen von dem vorherigen Bild zu dem momentanen Bild Mittel zum Speichern der Veränderungen in den aufeinanderfolgenden Kombinationen als Tabelle umfassen, um so eine Bewegung der Kante von einem Bild zu einem anderen Bild sequentiell darzustellen.

11. Verfahren zum Dekomprimieren von digitalen Farbvideodaten, die unter Verwendung eines Kompressionsverfahrens komprimiert wurden, wobei die Videodaten eine erste Mehrzahl von digitalisierten Signalen umfassen, welche Kombinationen von Pixellauflängen und entsprechenden komprimierten digitalen Farbcodes für wenigstens einen Teil einer Mehrzahl von Abtastzeilen eines ersten Videobilds darstellen, sowie Kombinationen von Pixellauflängen und entsprechenden komprimierten digitalen Farbcodes umfassen, welche sich für nachfolgende Videobilder verändert haben, wobei das Kompressionsverfahren eine erste Nachschlagetabelle (120) von komprimierten digitalen Farbcodes für drei entsprechende digitale Farbkomponenten verwendet, wobei die komprimierten digitalen Farbcodes eine ausgewählte Zahl von Farbkombinationen für die drei digitalen Farbkomponenten darstellen, wobei diese ausgewählte Zahl im voraus nach den visuell bedeutsamsten Farbkombinationen, welche voraussichtlich in dem Bild vorkommen, festgelegt wird, wobei jede Lauflänge diejenige Zahl von aufeinanderfolgenden Pixeln umfaßt, welche die selben komprimierten digitalen Farbcodes aufweisen, wobei die entsprechenden komprimierten digitalen Farbcodes ausgewählte der komprimierten digitalen Farbcodes der ersten Nachschlagetabelle (120) darstellen, wobei die Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbcodes eine erste Digitalwortgröße besitzen, und die entsprechenden komprimierten digitalen Farbcodes eine zweite Digitalwortgröße besitzen, wobei das Verfahren die Schritte umfaßt:

a) Empfangen der ersten Mehrzahl von digitalisierten Signalen, welche Lauflängen und entsprechende komprimierte digitale Farbcodes für wenigstens einen Teil einer Mehrzahl von Abtastzeilen eines ersten Bilds darstellen,
b) Empfangen von Veränderungen in Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbcodes, und zwar Veränderungen von dem Teil einer Mehrzahl von Abtastzeilen des ersten Bilds zu einem entsprechenden Teil einer Mehrzahl von Abtastzeilen eines momentanen Bilds,
c) Erstellen einer zweiten Mehrzahl von digitalisierten Signalen, welche das momentane Bild definieren, anhand der ersten Mehrzahl von digitalisierten Signalen, welche das erste Bild definieren, und der Veränderungen von dem ersten Bild zu dem momentanen Bild,
d) Decodieren der entsprechenden komprimierten digitalen Farbcodes der zweiten Mehrzahl von digitalisierten Signalen nach Maßgabe einer zweiten Nachschlagetabelle (248), welche der ersten Nachschlagetabelle (120) ähnlich ist, um die entsprechenden drei digitalen Farbkomponenten für jede Lauflänge zu erhalten, wobei die entsprechenden drei digitalen Farbkomponenten eine dritte, vierte bzw. fünfte Digitalwortgröße besitzen,
e) Speichern der Lauflängen und der entsprechenden drei digitalen Farbkomponenten in einem Feld in einer Pufferspeichereinrichtung (58, 60, 158, 160),
f) Erzeugen eines Farbvideoanzeigesignals aus den Lauflängen und den entsprechenden drei digitalen Farbkomponenten für das momentane Bild durch Erzeugen der Pixel in jeder Lauflänge von einem Startpixel für die Lauflänge zu einem Endpixel für die Lauflänge und
g) Wiederholen der Schritte b) bis f) für nachfolgende Videobilder.

12. Verfahren nach Anspruch 11, bei dem der Schritt der Erzeugung eines Farbvideoanzeigesignals aus den Lauflängen und den entsprechenden drei digitalen Farbkomponenten die Schritte umfaßt: Erzeugen des Startpixels für jede Lauflänge unter Verwendung der entsprechenden drei digitalen Farbkomponenten und Erzeugen der verbleibenden Pixel in der Lauflänge durch Interpolieren eines weichen Farbübergangs zu dem Startpixel der nächsten Lauflänge.

13. Verfahren nach Anspruch 11, bei dem der Schritt

des Speicherns der Lauflängen und der entsprechenden drei digitalen Farbkomponenten in einem Feld in einer Pufferspeichereinrichtung (58, 60, 158, 160) die Schritte umfaßt: Speichern der Lauflängen und der entsprechenden drei digitalen Farbkomponenten in einem ersten Pufferspeicher (58, 158), bis ein erster Satz von Daten für ein erstes Bild vollständig ist, Speichem der Lauflängen und der entsprechenden drei digitalen Farbkomponenten eines nächsten Satzes von Bilddaten in einem zweiten Pufferspeicher (60, 160), bis dieses nächste Bild vollständig ist, und Wiederholen der Schritte des Speicherns in dem ersten und dem zweiten Pufferspeicher (58, 60, 158, 160) für nachfolgende Bilddaten.

**14.** Verfahren nach Anspruch 11, bei dem im Rahmen des Kompressionsverfahrens die Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbcodes der digitalisierten Signale in einer Tabelle formuliert worden sind, welche Abtastzeilen darstellt, die sich von einer Abtastzeile in einem Bild zu der in Abtastrichtung nächsten benachbarten Abtastzeile nicht unterscheiden, und dies für jedes Bild, wobei das Verfahren weiter die Schritte umfaßt: Decodieren der Tabelle von Lauflängen und entsprechenden komprimierten digitalen Farbcodes und Erzeugen von Lauflängen und entsprechenden komprimierten Farbcodes für die benachbarten Abtastzeilen.

**15.** Verfahren nach Anspruch 11, bei dem im Rahmen des Kompressionsverfahrens charakteristische Kanten einer bildhaften Darstellung, die sich bewegt haben und als aufeinanderfolgende Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbcodes in wenigstens einer Abtastzeile bestimmt wurden, in eine Tabelle für jedes Bild eingefügt worden sind, welche Veränderungen in den aufeinanderfolgenden Kombinationen darstellt, um so eine Bewegung der Kanten von einem Bild zu einem anderen Bild darzustellen, wobei das Verfahren ferner den Schritt der Speicherung dieser Veränderungen in den aufeinanderfolgenden Kombinationen in einem Feld umfaßt.

**16.** System zum Dekomprimieren von in einem Kompressionssystem komprimierten Farbvideodaten, wobei die Videodaten eine erste Mehrzahl von digitalisierten Signalen umfassen, welche Kombinationen von Pixellauflängen und entsprechenden komprimierten digitalen Farbcodes für wenigstens einen Teil einer Mehrzahl von Abtastzeilen eines ersten Videobilds darstellen, und Kombinationen von Pixellauflängen und entsprechenden komprimierten digitalen Farbcodes umfassen, welche sich für nachfolgende Videobilder geändert haben, wobei das Kompressionssystem eine erste Nachschlagetabelle (120) von komprimierten digitalen Farbcodes für drei entsprechende digitale Farbkomponenten umfaßt, wobei die komprimierten digitalen Farbcodes eine ausgewählte Zahl von Farbkombinationen für die drei digitalen Farbkomponenten darstellen, wobei die ausgewählte Zahl im voraus nach den visuell bedeutsamsten Farbkombinationen, die voraussichtlich in dem Bild vorkommen, festgelegt wird, wobei jede Lauflänge diejenige Zahl von aufeinanderfolgenden Pixeln umfaßt, welche die selben komprimierten digitalen Farbcodes aufweisen, wobei die entsprechenden komprimierten digitalen Farbcodes ausgewählte der komprimierten digitalen Farbcodes der ersten Nachschlagetabelle darstellen, wobei die Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbkomponentencodes eine erste Digitalwortgröße besitzen und wobei die entsprechenden komprimierten digitalen Farbcodes eine zweite Digitalwortgröße besitzen, wobei das System ferner umfaßt:

a) Empfangsmittel (52) zum Empfangen der ersten Mehrzahl von digitalisierten Signalen, welche Lauflängen und entsprechende komprimierte digitale Farbcodes für wenigstens einen Teil einer Mehrzahl von Abtastzeilen eines ersten Bilds darstellen,
b) Mittel (236) zum Empfangen von Veränderungen in Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbcodes, nämlich Veränderungen von dem Teil einer Mehrzahl von Abtastzeilen des ersten Bilds zu einem entsprechenden Teil einer Mehrzahl von Abtastzeilen eines momentanen Bilds,
c) Mittel (45, 145) zum Erstellen einer zweiten Mehrzahl von digitalisierten Signalen, welche das momentane Bild definieren, anhand der ersten Mehrzahl von digitalisierten Signalen, die das erste Bild definieren, und der Veränderungen von dem ersten Bild zu dem momentanen Bild,
d) Mittel (56, 248) zum Decodieren der entsprechenden komprimierten digitalen Farbcodes der zweiten Mehrzahl von digitalisierten Signalen nach Maßgabe einer zweiten Nachschlagetabelle (248), welche der ersten Nachschlagetabelle (120) ähnlich ist, um die entsprechenden drei digitalen Farbkomponenten für jede Lauflänge zu erhalten, wobei die entsprechenden drei digitalen Farbkomponenten eine dritte, vierte bzw. fünfte Digitalwortgröße besitzen,
e) Mittel (54, 154, 250) zum Speichern der Lauflängen und der entsprechenden drei digitalen Farbkomponenten in einem Feld in einer Pufferspeichereinrichtung (58, 60, 158, 160) und
f) Mittel (61, 161) zum Erzeugen eines Farbvideoanzeigesignals aus der Lauflänge und den entsprechenden drei digitalen Farbkomponen-

ten für das momentane Bild durch Erzeugen der Pixel in jeder Lauflänge von einem Startpixel für die Lauflänge zu einem Endpixel für die Lauflänge und zum analogen Erzeugen von Farbvideoanzeigesignalen für alle nachfolgenden Bilder.

17. System nach Anspruch 16, bei dem die Mittel (61, 161) zum Erzeugen eines Farbvideoanzeigesignals aus der Lauflänge und den entsprechenden drei digitalen Farbkomponenten Mittel zum Erzeugen des Startpixels für jede Lauflänge unter Verwendung der entsprechenden drei digitalen Farbkomponenten umfassen sowie Mittel zum Erzeugen der verbleibenden Pixel in der Lauflänge durch Interpolieren eines weichen Farbübergangs zum Startpixel der nächsten Lauflänge umfassen.

18. System nach Anspruch 16, bei dem die Mittel (54, 154, 250) zum Speichern der Lauf längen und der entsprechenden drei digitalen Farbkomponenten in einem Feld in einer Pufferspeichereinrichtung (58, 60, 158, 160) Mittel zum Speichern der Lauflängen und der entsprechenden drei digitalen Farbkomponenten in einem ersten Pufferspeicher (58, 158), bis ein erster Satz der Daten für ein erstes Bild vollständig ist, zum Speichern der Lauflängen und der entsprechenden drei digitalen Farbkomponenten eines nächsten Satzes von Bilddaten in einem zweiten Pufferspeicher (60, 160), bis das nächste Bild vollständig ist, und zum Wiederholen der Schritte des Speicherns in dem ersten und dem zweiten Pufferspeicher (18, 60, 158, 160) für nachfolgende Bilddaten umfassen.

19. System nach Anspruch 16, bei dem in dem Kompressionssystem die Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbcodes der digitalisierten Signale in einer Tabelle formuliert worden sind, welche Abtastzeilen darstellt, die sich von einer Abtastzeile in einem Bild zu der in Abtastrichtung nächsten benachbarten Abtastzeile nicht unterscheiden, und zwar für jedes Bild, wobei das System ferner Mittel (24) zum Decodieren der Tabelle von Lauflängen und entsprechenden komprimierten digitalen Farbcodes umfaßt sowie Mittel zum Erzeugen von Lauflängen und entsprechenden komprimierten Farbcodes für die benachbarten Abtastzeilen umfaßt.

20. System nach Anspruch 16, bei dem in dem Kompressionssystem charakteristische Kanten einer bildhaften Darstellung, die sich bewegt haben und als aufeinanderfolgende Kombinationen von Lauflängen und entsprechenden komprimierten digitalen Farbcodes in wenigstens einer Abtastzeile bestimmt wurden, in eine Tabelle für jedes Bild eingefügt worden sind, welche Veränderungen in den aufeinanderfolgenden Kombinationen darstellt, um so eine Bewegung der Ränder von einem Bild zu einem anderen Bild darzustellen, wobei das System ferner Mittel (242) zum Speichern der Veränderungen in den aufeinanderfolgenden Kombinationen in einem Feld umfaßt.

**Revendications**

1. Procédé de compression de données vidéo couleur numériques comprenant un signal vidéo couleur pour une pluralité de trames d'image, chaque trame d'image comprenant une pluralité de lignes de balayage composées d'une pluralité de pixels, et chaque pixel de ladite trame d'image comprenant trois composantes de couleur numériques, ledit procédé comprenant les étapes :

   a) de détermination d'une valeur de luminance pour chaque pixel en fonction d'au moins l'une desdites trois composantes de couleur numériques ;

   b) d'évaluation d'au moins un paramètre de décision pour chaque pixel d'au moins une partie substantielle de chacune d'une pluralité de lignes de balayage d'une trame d'image courante, en déterminant la différence entre la valeur de luminance de chaque pixel et la valeur de luminance d'au moins un autre pixel de la même ligne de balayage ;

   c) de comparaison dudit au moins un paramètre de décision pour chaque pixel avec une valeur de seuil réglable correspondante pour déterminer quels pixels ont une valeur de luminance qui a varié, de plus qu'une valeur prédéterminée, par rapport à la valeur de luminance dudit au moins un autre pixel, chacun desdits pixels dont la valeur de luminance a ainsi varié étant soit un pixel de début soit un pixel de fin pour une longueur de séquence de pixels liés séquentiellement d'une dite ligne de balayage, ladite longueur de séquence étant représentée comme une première partie d'un signal numérique, ladite première partie ayant une première taille de mot numérique, chaque pixel dans chaque longueur de séquence étant défini comme ayant les mêmes trois composantes de couleur numériques, lesdites trois composantes de couleur numériques étant des deuxième, troisième et quatrième parties dudit signal numérique ayant, respectivement, des deuxième, troisième et quatrième tailles de mot numérique ;

   d) de codage desdites trois composantes de couleur numériques de chaque longueur de séquence de ladite trame d'image d'après une table de consultation de codes de couleur numé-

riques comprimés, d'une cinquième taille de mot numérique plus petite que la somme desdites deuxième, troisième et quatrième tailles de mot numérique ; lesdits codes de couleur numériques comprimés représentant un nombre choisi de combinaisons de couleurs, ledit nombre choisi étant prédéterminé comme étant les combinaisons de couleurs visuellement les plus significatives qui risquent d'apparaître dans ladite trame d'image ; ladite étape de codage comprenant l'étape de choix des codes de couleur numériques comprimés représentant la meilleure correspondance entre lesdites composantes de couleur numériques de chaque longueur de séquence et ledit nombre choisi de combinaisons de couleurs ;

e) de codage des trois composantes de couleur numériques de chaque ensemble desdits pixels liés séquentiellement, en tant que combinaison de la longueur de séquence et desdits codes de couleur numériques comprimés associés ;

f) de comparaison desdites longueurs de séquence et desdits codes de couleur numériques comprimés de ladite trame d'image courante avec les longueurs de séquence et les codes de couleur numériques comprimés d'une trame d'image précédente pour déterminer les variations de ladite trame d'image courante par rapport à ladite trame d'image précédente ; et

g) 'de codage desdites variations de ladite trame d'image courante par rapport à ladite trame d'image précédente pour au moins une partie desdites trames d'image, ce par quoi une fois que l'on a codé une trame d'image initiale, seules les variations dans les trames d' image ultérieures sont codées.

2. Procédé selon la revendication 1, dans lequel ladite étape de comparaison dudit au moins un paramètre de décision avec une valeur de seuil réglable correspondante comprend les étapes : de détermination des taux de variation des différences dudit au moins un paramètre de décision entre les pixels de ladite partie substantielle de ladite ligne de balayage pour chacun desdits pixels, et de comparaison de chacun desdits taux de variation avec un taux réglable correspondant de seuil de variation, pour déterminer lesquels desdits pixels ont une variation prédéterminée de luminance et comprennent lesdits pixels de début et de fin.

3. Procédé selon la revendication 1, dans lequel ladite étape de comparaison dudit au moins un paramètre de décision, pour chaque pixel, avec une valeur de seuil réglable correspondante comprend l'étape de comparaison des valeurs d'une pluralité desdits paramètres de décision avec une pluralité correspondante de seuils, pour déterminer quels pixels ont une variation prédéterminée de luminance et comprennent lesdits pixels de début et lesdits pixels de fin.

4. Procédé selon la revendication 1, comprenant en outre, après l'étape e), les étapes de comparaison des pixels de lignes de balayage adjacentes, et de formulation, pour chaque trame d'image, d'une table de longueurs de séquence et de codes de couleur numériques comprimés représentant des lignes de balayage d'une trame d'image, qui ne diffèrent pas d'une ligne de balayage à la ligne de balayage adjacente suivante dans la direction de balayage.

5. Procédé selon la revendication 1, dans lequel ladite étape de comparaison dudit au moins un paramètre de décision avec une valeur de seuil réglable correspondante comprend, en outre, l'étape de détection, pour chaque trame d'image, des bords d'une image sous forme de combinaisons successives desdites longueurs de séquence et desdits codes de couleur numériques comprimés d'au moins une ligne balayage, lesdites combinaisons successives étant liées en fonction d'un critère prédéfini qui identifie les combinaisons successives comme un bord ; et dans lequel ladite étape de codage desdites variations de ladite trame d'image courante par rapport à ladite trame d'image précédente comprend, en outre, la mémorisation des variations desdites combinaisons successives dans une table de façon à représenter séquentiellement un mouvement dudit bord, d'une trame à une autre trame.

6. Système pour comprimer des données vidéo couleur numériques comprenant un signal vidéo couleur pour une pluralité de trames d'image, chaque trame d'image comprenant une pluralité de lignes de balayage composées d'une pluralité de pixels, et chaque pixel de ladite trame d'image comprenant trois composantes de couleur numériques, ledit système comprenant :

a) un moyen de détermination (18 ; 118) pour déterminer une valeur de luminance pour chaque pixel en utilisant au moins l'une desdites trois composantes de couleur numériques ;

b) un moyen d'évaluation (26 ; 126) pour évaluer au moins un paramètre de décision pour chaque pixel d'au moins une partie substantielle de chacune d'une pluralité de lignes de balayage d'une trame d'image courante, en déterminant la différence entre la valeur de luminance de chaque pixel et la valeur de luminance d'au moins un autre pixel de la même ligne de balayage ;

c) un moyen de comparaison (29 ; 129) pour

comparer ledit au moins un paramètre de décision pour chaque pixel avec une valeur de seuil réglable correspondante pour déterminer quels pixels ont une valeur de luminance qui a varié, de plus qu'une valeur prédéterminée, par rapport à la valeur de luminance dudit au moins un autre pixel, chacun desdits pixels dont la valeur de luminance a ainsi varié étant soit un pixel de début soit un pixel de fin pour une longueur de séquence de pixels liés séquentiellement d'une dite ligne de balayage, ladite longueur de séquence étant représentée comme une première partie d'un signal numérique, ladite première partie ayant une première taille de mot numérique, chaque pixel dans ladite longueur de séquence étant défini comme ayant les mêmes trois composantes de couleur numériques, lesdites trois composantes de couleur numériques étant des deuxième, troisième et quatrième parties dudit signal numérique ayant, respectivement, des deuxième, troisième et quatrième tailles de mot numérique ;

d) un moyen de codage (212 ; 214) pour coder lesdites trois composantes de couleur numériques de chaque longueur de séquence de ladite trame d'image d'après une table de consultation (120) de codes de couleur numériques comprimés, d'une cinquième taille de mot numérique plus petite que la somme desdites deuxième, troisième et quatrième tailles de mot numérique ; lesdits codes de couleur numériques comprimés représentant un nombre choisi de combinaisons de couleurs, ledit nombre choisi étant prédéterminé comme étant les combinaisons de couleurs visuellement les plus significatives qui risquent d'apparaître dans ladite trame d'image ; ledit moyen de codage (212 ; 214) comprenant un moyen de choix pour choisir les codes de couleur numériques comprimés représentant la meilleure correspondance entre lesdites composantes de couleur numériques de chaque longueur de séquence et ledit nombre choisi de combinaisons de couleurs ;

e) un moyen de codage (218) pour coder les trois composantes de couleur numériques de chaque ensemble desdits pixels liés séquentiellement, en tant que combinaison de la longueur de séquence et desdits codes de couleur numériques comprimés associés ;

f) un moyen de comparaison (222) pour comparer lesdites longueurs de séquence et lesdits codes de couleur numériques comprimés de ladite trame d'image courante avec les longueurs de séquence et les codes de couleur numériques comprimés d'une trame d'image précédente pour déterminer les variations de ladite trame d'image courante par rapport à ladite trame d'image précédente ; et

g) un moyen de codage (228) pour coder lesdites variations de ladite trame d'image courante par rapport à ladite trame d'image précédente pour au moins une partie desdites trames d'image, ce par quoi une fois que l'on a codé une trame d'image initiale, on code seulement les variations dans les trames d'image ultérieures.

7. Système selon la revendication 6, dans lequel ledit moyen de comparaison (222) pour comparer ledit au moins un paramètre de décision avec une valeur de seuil réglable correspondante comprend un moyen de détermination pour déterminer les taux de variation des différences dudit au moins un paramètre de décision entre les pixels de ladite partie substantielle de ladite ligne de balayage pour chacun desdits pixels, et un moyen de comparaison pour comparer chacun desdits taux de variation avec un taux réglable correspondant de seuil de variation, pour déterminer lesquels desdits pixels ont une variation prédéterminée de luminance et comprennent lesdits pixels de début et de fin.

8. Système selon la revendication 6, dans lequel ledit moyen de comparaison (222) pour comparer ledit au moins un paramètre de décision avec une valeur de seuil réglable correspondante comprend un moyen de comparaison pour comparer des valeurs d'une pluralité desdits paramètres de décision avec une pluralité correspondante de seuils, pour déterminer quels pixels ont une variation prédéterminée de luminance et représentent lesdits pixels de début et lesdits pixels de fin.

9. Système selon la revendication 6, comprenant, en outre, un moyen de réception (228) pour recevoir la sortie dudit moyen (218) de codage des trois composantes de couleur numériques et pour comparer les pixels de lignes de balayage adjacentes, et un moyen de formulation pour formuler, pour chaque trame d'image, une table de longueurs de séquence et de codes de couleur numériques comprimés représentant des lignes de balayage d'une trame d'image, qui ne diffèrent pas d'une ligne de balayage à la ligne de balayage adjacente suivante dans la direction de balayage.

10. Système selon la revendication 6, dans lequel ledit moyen de comparaison (29, 129) pour comparer ledit au moins un paramètre de décision à une valeur de seuil réglable correspondante comprend un moyen de détection pour détecter, pour chaque trame d'image, des bords d'une image sous forme de combinaisons successives desdites longueurs de séquence et desdits codes de couleur numériques comprimés d'au moins une ligne balayage, lesdites

combinaisons successives étant liées en fonction d'un critère prédéfini qui identifie les combinaisons successives comme un bord ; et dans lequel ledit moyen de codage (228) pour coder lesdites variations de ladite trame d'image courante par rapport à ladite trame d'image précédente comprend, en outre, un moyen de mémorisation pour mémoriser les variations desdites combinaisons successives sous forme d'une table de façon à représenter séquentiellement un mouvement dudit bord, d'une trame à une autre trame.

11. Procédé de décompression de données vidéo couleur numériques, comprimées en utilisant un procédé de compression, lesdites données vidéo comprenant une première pluralité de signaux numérisés représentant des combinaisons de longueurs de séquence de pixels et correspondant à des codes de couleur numériques comprimés pour au moins une partie d'une pluralité de lignes de balayage d'une première trame d'image vidéo, et des combinaisons de longueurs de séquence de pixels et des codes de couleur numériques comprimés correspondants qui ont varié pour des trames d'image vidéo ultérieures, ledit procédé de compression utilisant une première table de consultation (120) de codes de couleur numériques comprimés pour trois composantes de couleur numériques correspondantes, lesdits codes de couleur numériques comprimés représentant un nombre choisi de combinaisons de couleurs pour les trois composantes de couleur numériques, ledit nombre choisi étant prédéterminé comme étant les combinaisons de couleurs visuellement les plus significatives qui risquent d'apparaître dans ladite trame d'image, chacune desdites longueurs de séquence comprenant le nombre de pixels séquentiels qui ont les mêmes codes de couleur numériques comprimés, lesdits codes de couleur numériques comprimés représentant ceux qui sont choisis desdits codes de couleur numériques comprimés de ladite première table de consultation (120), lesdites combinaisons de longueurs de séquence et de codes de couleur numériques comprimés correspondants ayant une première taille de mot numérique, et lesdits codes de couleur numériques comprimés correspondants ayant une deuxième taille de mot numérique ;
le procédé comprenant les étapes :

a) de réception de ladite première pluralité desdits signaux numérisés représentant les longueurs de séquence et les codes de couleur numériques comprimés correspondants pour au moins une partie d'une pluralité de lignes de balayage d'une première trame d'image ;
b) de réception de variations des combinaisons de longueurs de séquence et de codes de couleur numériques comprimés correspondants par rapport à ladite partie d'une pluralité de lignes de balayage de ladite première trame d'image dans une partie correspondante d'une pluralité de lignes de balayage d'une trame d'image courante ;
c) de construction d'une seconde pluralité desdits signaux numérisés définissant ladite trame d'image courante à partir de ladite première pluralité de signaux numérisés définissant ladite première trame d'image et desdites variations de ladite trame d'image courante par rapport à ladite première trame d'image ;
d) de décodage desdits codes de couleur numériques comprimés correspondants de ladite seconde pluralité de signaux numérisés en fonction d'une seconde table de consultation (248) analogue à ladite première table de consultation (120) pour obtenir lesdites trois composantes de couleur numériques correspondantes pour chacune desdites longueurs de séquence, lesdites trois composantes de couleur numériques correspondantes ayant, respectivement, des troisième, quatrième et cinquième tailles de mot numérique ;
e) de mémorisation desdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes en un groupement dans un moyen formant mémoire tampon (58, 60, 158, 160);
f) de production d'un signal d'affichage vidéo couleur à partir desdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes pour ladite trame d'image courante en produisant les pixels de chacune desdites longueurs de séquence à partir d'un pixel de début de ladite longueur de séquence jusqu'à un pixel de fin de ladite longueur de séquence ; et
g) de répétition des étapes (b) à (f) pour les trames d'image vidéo ultérieures.

12. Procédé selon la revendication 11, dans lequel l'étape de production d'un signal d'affichage vidéo couleur à partir desdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes comprend les étapes : de production dudit pixel de début de chaque longueur de séquence en utilisant lesdites trois composantes de couleur numériques correspondantes ; et de production des pixels restants de ladite longueur de séquence par interpolation d'une transition de couleur régulière jusqu'au pixel de début de la longueur de séquence suivante.

13. Procédé selon la revendication 11, dans lequel ladite étape de mémorisation desdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes en un groupement

dans un moyen formant mémoire tampon (58, 60, 158, 160) comprend les étapes : de mémorisation desdites longueurs de séquence et desdites trois composantes de couleurs numérique correspondantes dans une première mémoire tampon (58, 158) jusqu'à la fin d'un premier ensemble desdites données pour une première trame d'image ; de mémorisation desdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes d'un ensemble suivant de données de trame d'image dans une seconde mémoire tampon (60, 160) jusqu'à la fin de ladite trame d'image suivante ; et de répétition desdites étapes de mémorisation dans lesdites première et seconde mémoires tampons (58, 60, 158, 160) pour les données de trame d'image ultérieures.

**14.** Procédé selon la revendication 11, dans lequel, dans ledit procédé de compression, lesdites combinaisons de longueurs de séquence et de codes de couleur numériques comprimés correspondants desdits signaux numérisés ont été formulés, pour chaque trame d'image, dans une table représentant des lignes de balayage d'une trame d'image, qui ne diffèrent pas d'une ligne de balayage à la ligne de balayage adjacente suivante dans la direction de balayage ; le procédé comprenant, en outre, les étapes : de décodage de ladite table de longueurs de séquence et de codes de couleur numériques comprimés correspondants, et de production de longueurs de séquence et de codes de couleur comprimés correspondants pour lesdites lignes de balayage adjacentes.

**15.** Procédé selon la revendication 11, dans lequel, dans ledit procédé de compression, des bords distinctifs d'une image qui se sont déplacés, déterminés comme des combinaisons successives desdites longueurs de séquence et desdits codes de couleur numériques comprimés correspondants d'au moins une ligne de balayage, ont été, pour chaque trame d'image, inclus dans une table représentant des variations desdites combinaisons successives, de manière à représenter le déplacement desdits bords, d'une trame d'image à une autre trame d'image, le procédé comprenant, en outre, l'étape de mémorisation, en un groupement, desdites variations desdites combinaisons successives.

**16.** Système pour décomprimer des données vidéo couleur numériques, comprimées dans un système de compression, lesdites données vidéo comprenant une première pluralité de signaux numérisés représentant des combinaisons de longueurs de séquence de pixels et correspondant à des codes de couleur numériques comprimés pour au moins une partie d'une pluralité de lignes de balayage d'une première trame d'image vidéo, et des combinaisons de longueurs de séquence de pixels et des codes de couleur numériques comprimés correspondants qui ont varié pour des trames d'image vidéo ultérieures, ledit procédé de compression utilisant une première table de consultation (120) de codes de couleur numériques comprimés pour trois composantes de couleur numériques correspondantes, lesdits codes de couleur numériques comprimés représentant un nombre choisi de combinaisons de couleurs pour les trois composantes de couleur numériques, ledit nombre choisi étant prédéterminé comme étant les combinaisons de couleurs visuellement les plus significatives qui risquent d'apparaître dans ladite trame d'image, chacune desdites longueurs de séquence comprenant le nombre de pixels séquentiels qui ont les mêmes codes de couleur numériques comprimés, lesdits codes de couleur numériques comprimés représentant ceux qui sont choisis desdits codes de couleur numériques comprimés de ladite première table de consultation, lesdites combinaisons de longueurs de séquence et de codes de couleur numériques comprimés correspondants ayant une première taille de mot numérique, et lesdits codes de couleur numériques comprimés correspondants ayant une deuxième taille de mot numérique ; ledit système comprenant :

a) un moyen de réception (52) pour recevoir ladite première pluralité desdits signaux numérisés représentant les longueurs de séquence et les codes de couleur numériques comprimés correspondants pour au moins une partie d'une pluralité de lignes de balayage d'une première trame d'image ;
b) un moyen de réception (236) pour recevoir des variations des combinaisons de longueurs de séquence et de codes de couleur numériques comprimés correspondants par rapport à ladite partie d'une pluralité de lignes de balayage de ladite première trame d'image dans une partie correspondante d'une pluralité de lignes de balayage d'une trame d'image courante ;
c) un moyen de construction (45, 145) pour construire une seconde pluralité desdits signaux numérisés définissant ladite trame d'image courante à partir de ladite première pluralité de signaux numérisés définissant ladite première trame d'image et desdites variations de ladite trame d'image courante par rapport à ladite première trame d'image ;
d) un moyen de décodage (56, 248) pour décoder lesdits codes de couleur numériques comprimés correspondants de ladite seconde pluralité de signaux numérisés en fonction d'une seconde table de consultation (248) analogue à ladite première table de consultation (120) pour obtenir lesdites trois composantes

de couleur numériques correspondantes pour chacune desdites longueurs de séquence, lesdites trois composantes de couleur numériques correspondantes ayant, respectivement, des troisième, quatrième et cinquième tailles de mot numérique ;

e) un moyen de mémorisation (54, 154, 250) pour mémoriser lesdites longueurs de séquence et lesdites trois composantes de couleur numériques correspondantes en un groupement dans un moyen formant mémoire tampon (58, 60, 158, 160) ; et

f) un moyen générateur (61, 161) pour produire un signal d'affichage vidéo couleur à partir desdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes pour ladite trame d'image courante en produisant les pixels de chacune desdites longueurs de séquence à partir d'un pixel de début de ladite longueur de séquence jusqu'à un pixel de fin de ladite longueur de séquence, et pour produire de manière correspondante des signaux d'affichage vidéo couleur pour toutes les trames d'image ultérieures.

**17.** Système selon la revendication 16, dans lequel ledit moyen générateur (61, 161) pour produire un signal d'affichage vidéo couleur à partir desdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes comprend un moyen générateur pour produire ledit pixel de début de chaque longueur de séquence en utilisant lesdites trois composantes de couleur numériques correspondantes ; et un moyen générateur pour produire les pixels restants de ladite longueur de séquence par interpolation d'une transition de couleur régulière jusqu'au pixel de début de la longueur de séquence suivante.

**18.** Système selon la revendication 16, dans lequel ledit moyen de mémorisation (54, 154, 250) pour mémoriser lesdites longueurs de séquence et desdites trois composantes de couleur numériques correspondantes en un groupement dans un moyen formant mémoire tampon (58, 60, 158, 160) comprend un moyen de mémorisation pour mémoriser lesdites longueurs de séquence et lesdites trois composantes de couleurs numérique correspondantes dans une première mémoire tampon (58, 158) jusqu'à la fin d'un premier ensemble desdites données pour une première trame d'image ; pour mémoriser lesdites longueurs de séquence et lesdites trois composantes de couleur numériques correspondantes d'un ensemble suivant de données de trame d'image dans une seconde mémoire tampon (60, 160) jusqu'à la fin de ladite trame d'image suivante ; et pour répéter lesdites étapes de mémorisation dans lesdites première et seconde mémoires tampons (58, 60, 158, 160) pour les données de trame d'image ultérieures.

**19.** Système selon la revendication 16, dans lequel, dans ledit système de compression, lesdites combinaisons de longueurs de séquence et de codes de couleur numériques comprimés correspondants desdits signaux numérisés ont été formulés, pour chaque trame d'image, dans une table représentant des lignes de balayage d'une trame d'image, qui ne diffèrent pas d'une ligne de balayage à la ligne de balayage adjacente suivante dans la direction de balayage ; le système comprenant, en outre, un moyen de décodage (24) pour décoder ladite table de longueurs de séquence et de codes de couleur numériques comprimés correspondants, et un moyen générateur pour produire des longueurs de séquence et des codes de couleur comprimés correspondants pour lesdites lignes de balayage adjacentes.

**20.** Système selon la revendication 16, dans lequel, dans ledit système de compression, des bords distinctifs d'une image qui se sont déplacés, déterminés comme des combinaisons successives desdites longueurs de séquence et desdits codes de couleur numériques comprimés correspondants d'au moins une ligne de balayage, ont été, pour chaque trame d'image, inclus dans une table représentant des variations desdites combinaisons successives, de manière à représenter le déplacement desdits bords, d'une trame d'image à une autre trame d'image, le système comprenant, en outre, un moyen de mémorisation (242) pour mémoriser, en un groupement, lesdites variations desdites combinaisons successives.

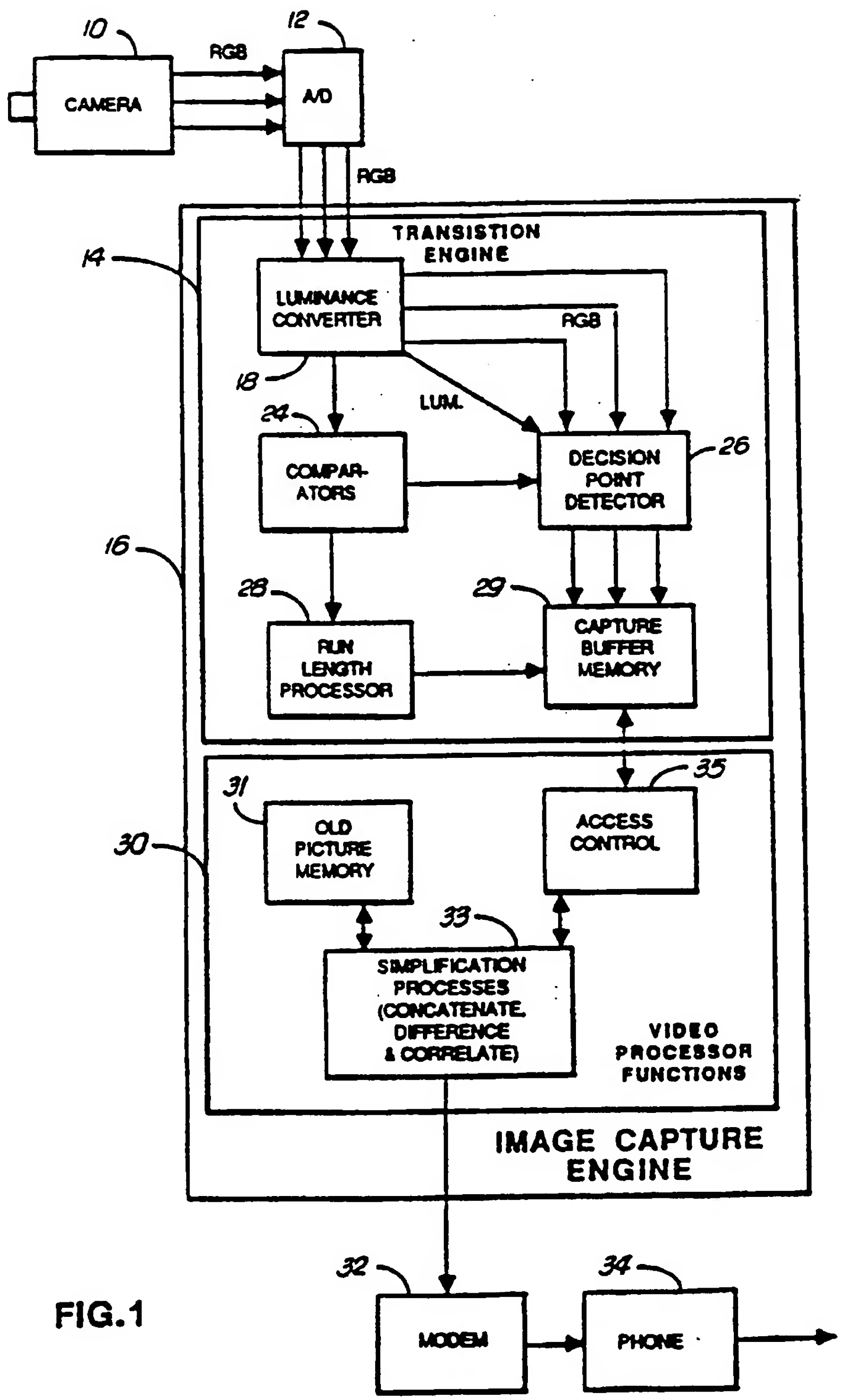
10
12
RGB
CAMERA
A/D
RGB
14
TRANSISTION ENGINE
LUMINANCE CONVERTER
RGB
18
LUM.
24
COMPAR-ATORS
DECISION POINT DETECTOR
26
16
28
29
RUN LENGTH PROCESSOR
CAPTURE BUFFER MEMORY
35
31
OLD PICTURE MEMORY
ACCESS CONTROL
30
33
SIMPLIFICATION PROCESSES (CONCATENATE, DIFFERENCE & CORRELATE)
VIDEO PROCESSOR FUNCTIONS
IMAGE CAPTURE ENGINE
32
34
MODEM
PHONE

FIG.1

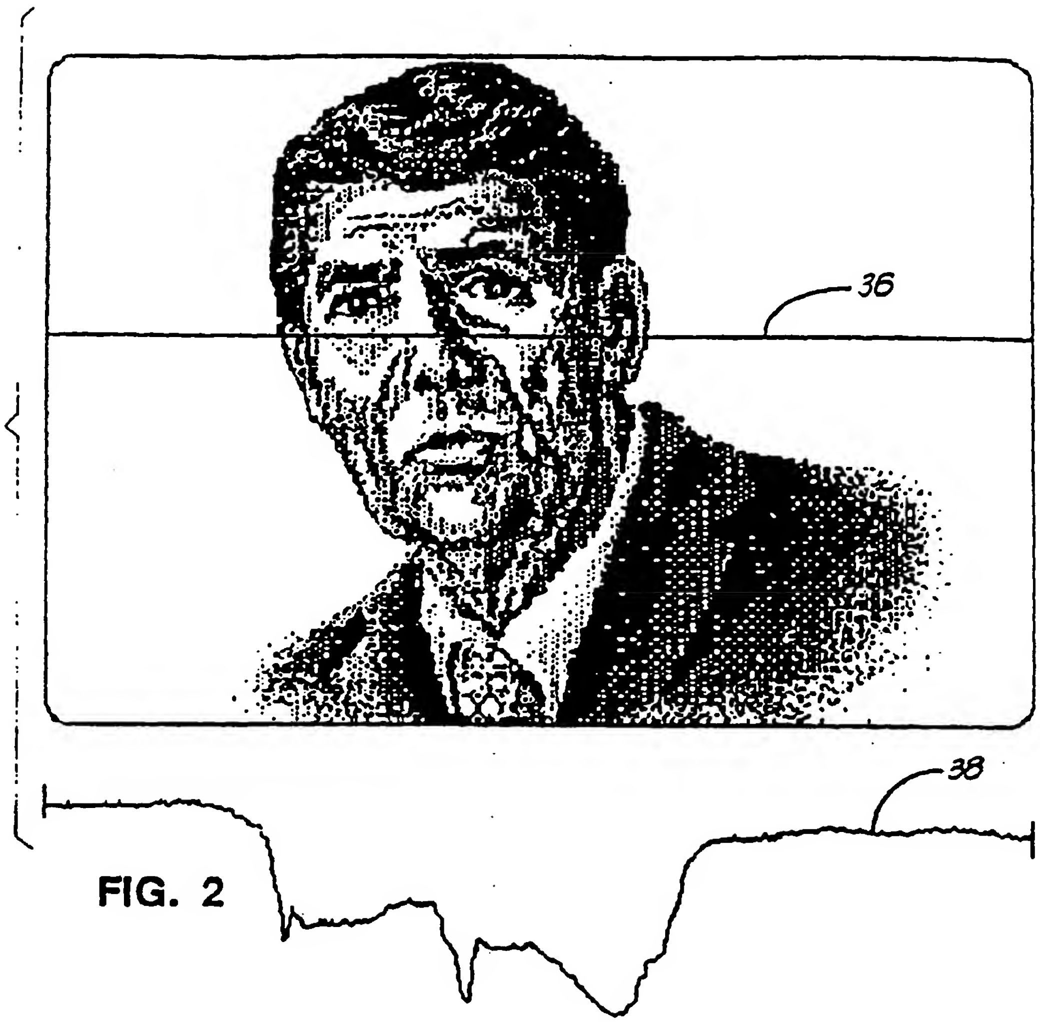


FIG. 2


FIG. 3

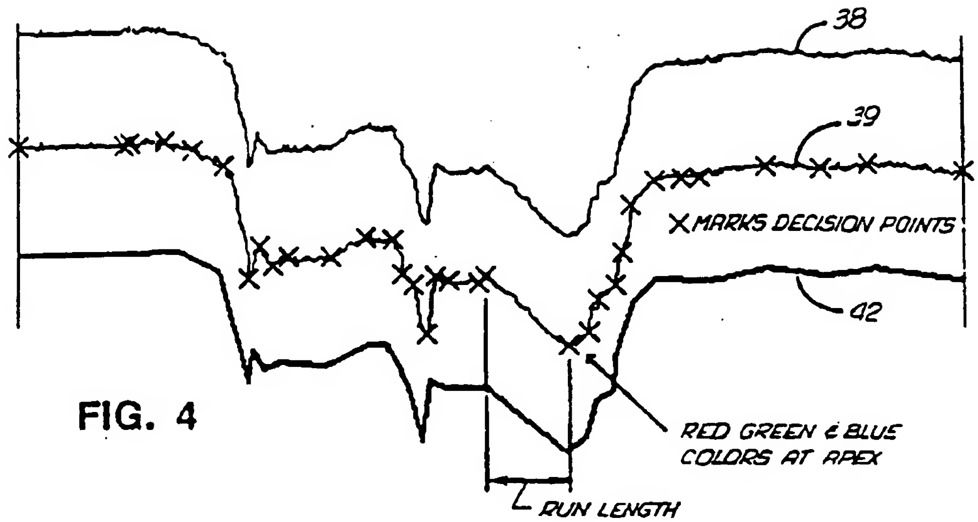


FIG. 4

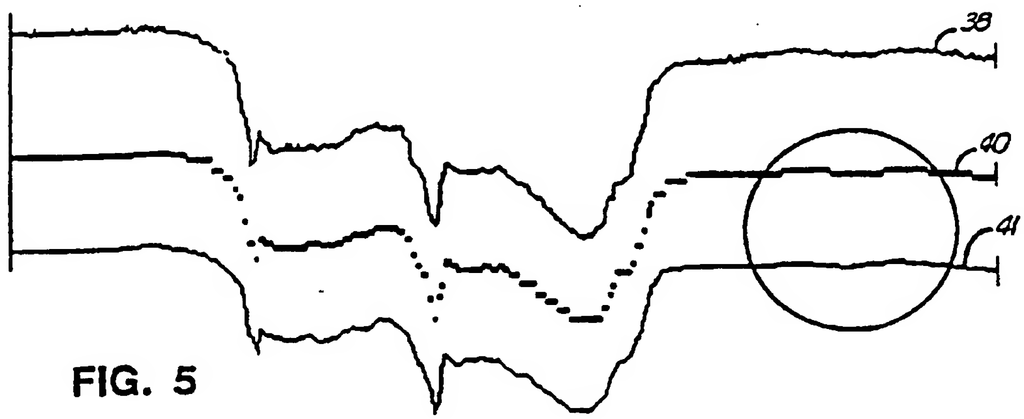


FIG. 5

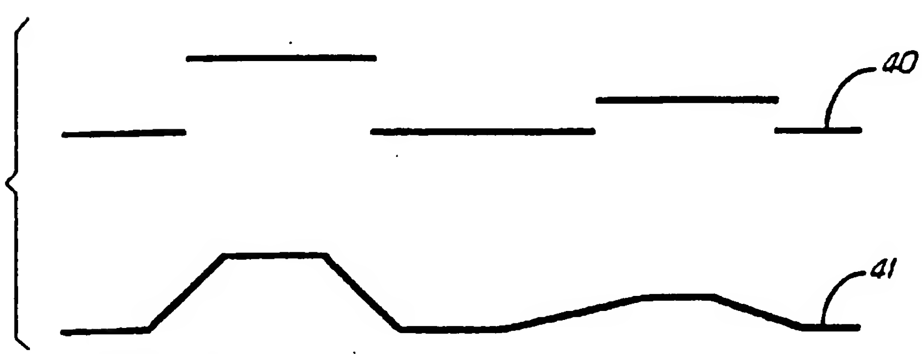


FIG. 6

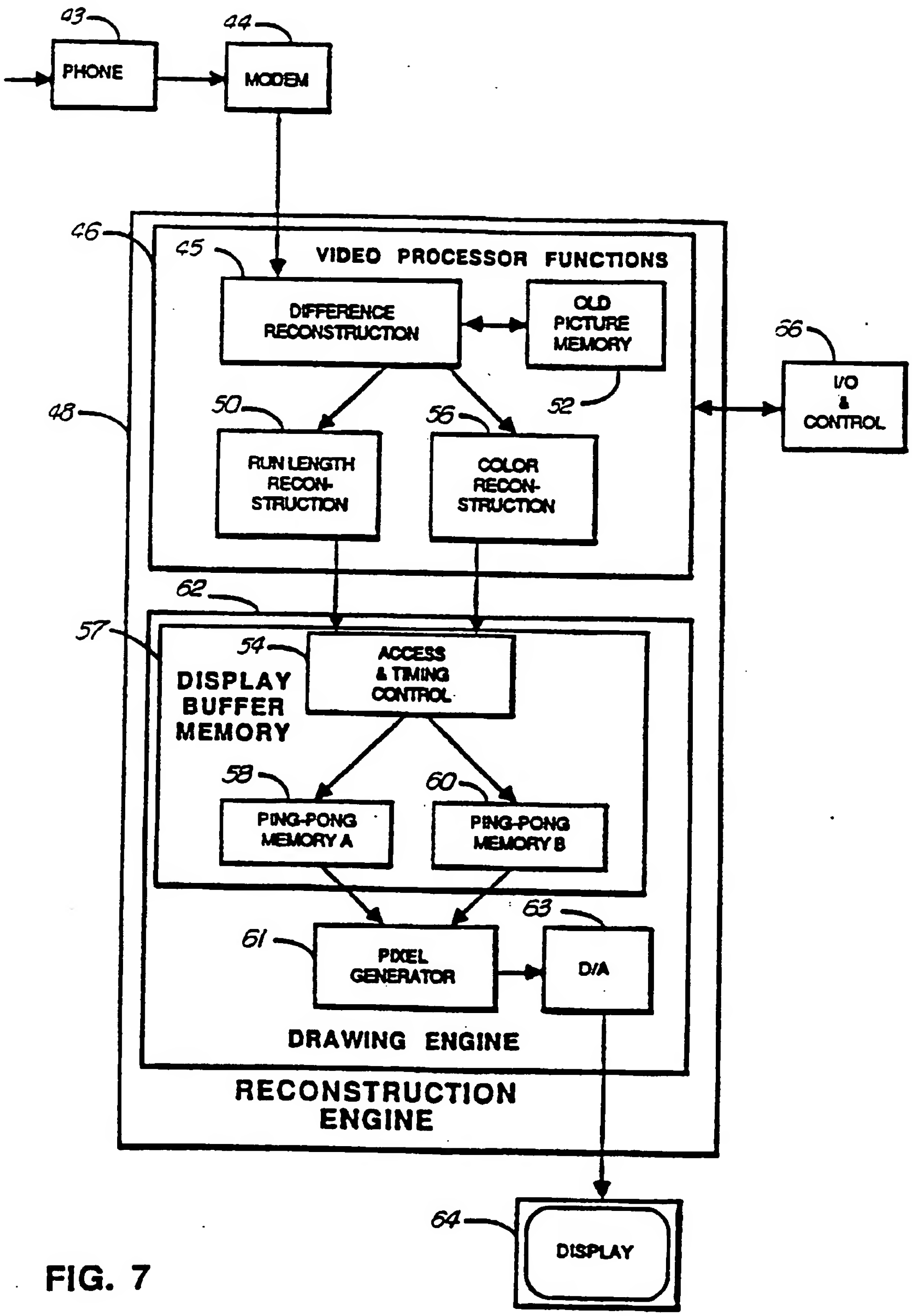
43
44
PHONE
MODEM
46
45
VIDEO PROCESSOR FUNCTIONS
DIFFERENCE RECONSTRUCTION
OLD PICTURE MEMORY
56
I/O & CONTROL
48
50
56
52
RUN LENGTH RECON-STRUCTION
COLOR RECON-STRUCTION
62
57
54
ACCESS & TIMING CONTROL
DISPLAY BUFFER MEMORY
58
60
PING-PONG MEMORY A
PING-PONG MEMORY B
63
61
PIXEL GENERATOR
D/A
DRAWING ENGINE
RECONSTRUCTION ENGINE
64
DISPLAY

FIG. 7

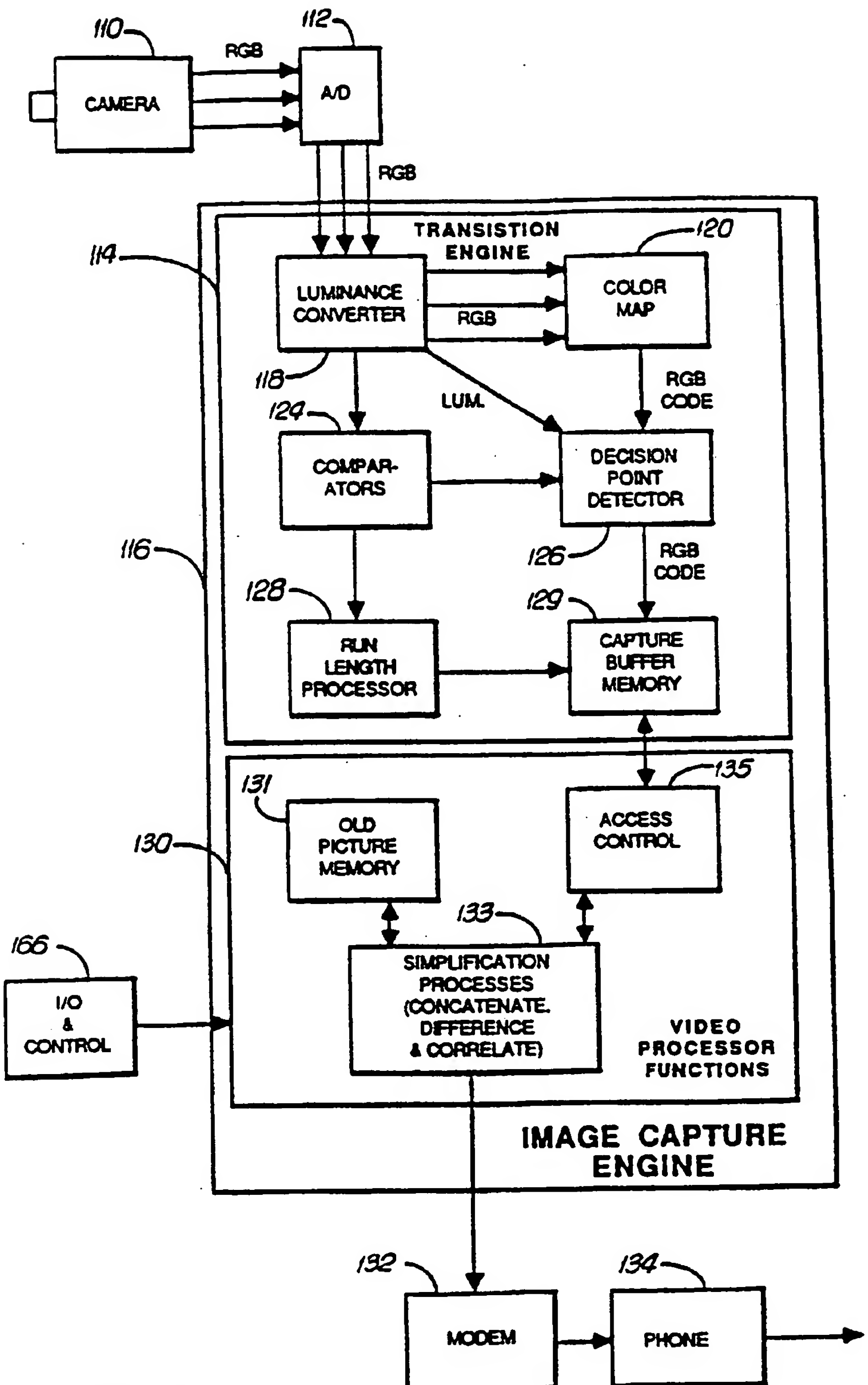
110
112
RGB
CAMERA
A/D
RGB
114
TRANSISTION ENGINE
120
LUMINANCE CONVERTER
RGB
COLOR MAP
118
124
LUM.
RGB CODE
COMPAR-ATORS
DECISION POINT DETECTOR
116
126
RGB CODE
128
129
RUN LENGTH PROCESSOR
CAPTURE BUFFER MEMORY
131
135
130
OLD PICTURE MEMORY
ACCESS CONTROL
133
166
SIMPLIFICATION PROCESSES (CONCATENATE. DIFFERENCE & CORRELATE)
I/O & CONTROL
VIDEO PROCESSOR FUNCTIONS
IMAGE CAPTURE ENGINE
132
134
MODEM
PHONE

FIG. 8

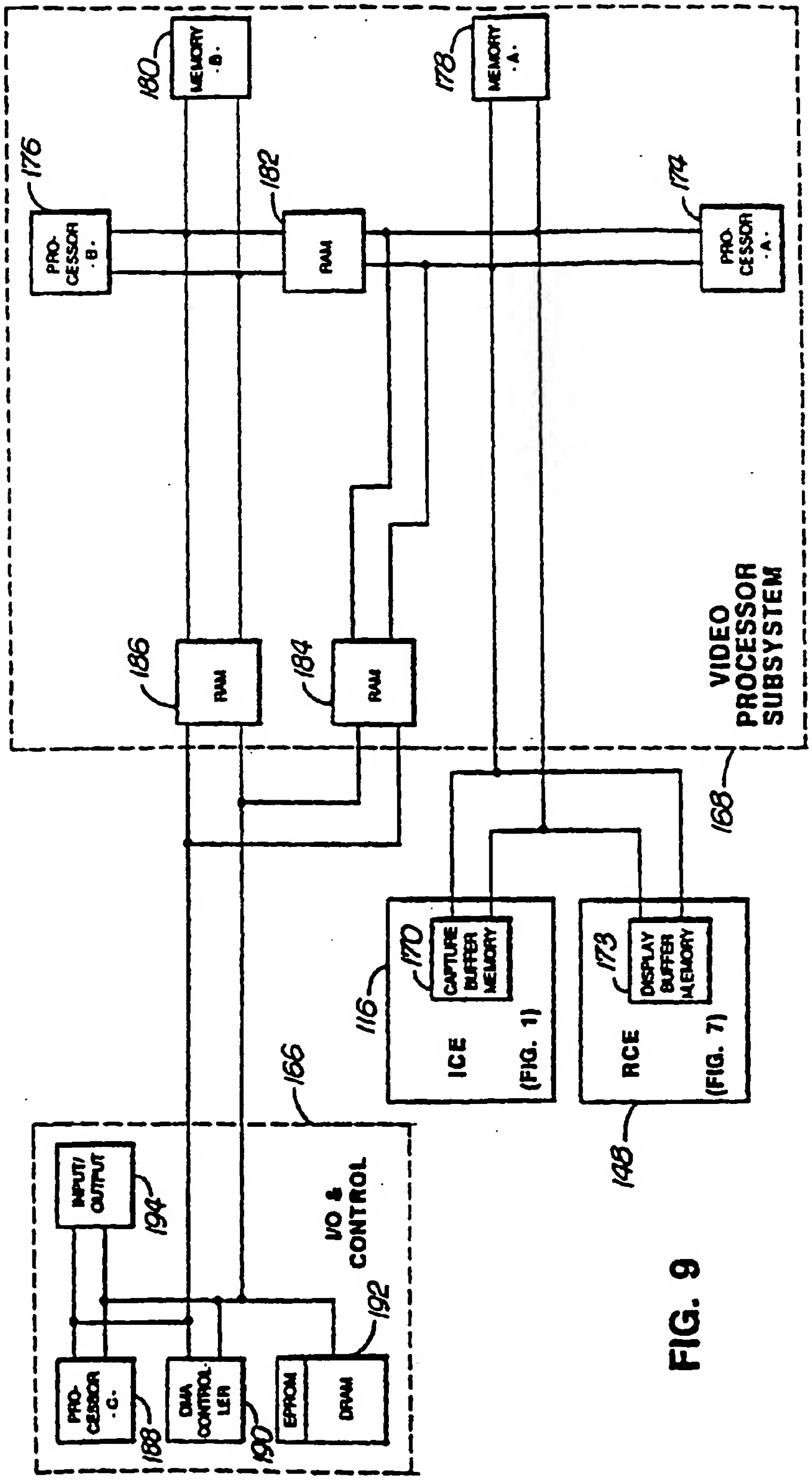
PRO-CESSOR ·B·
176
MEMORY ·B·
180
RAM
182
MEMORY ·A·
178
PRO-CESSOR ·A·
174
RAM
186
RAM
184
VIDEO PROCESSOR SUBSYSTEM
168
CAPTURE BUFFER MEMORY
170
ICE
(FIG. 1)
116
DISPLAY BUFFER MEMORY
173
RCE
(FIG. 7)
148
INPUT/OUTPUT
194
I/O & CONTROL
166
PRO-CESSOR ·C·
188
DMA CONTROL-LER
190
EPROM
DRAM
192

FIG. 9

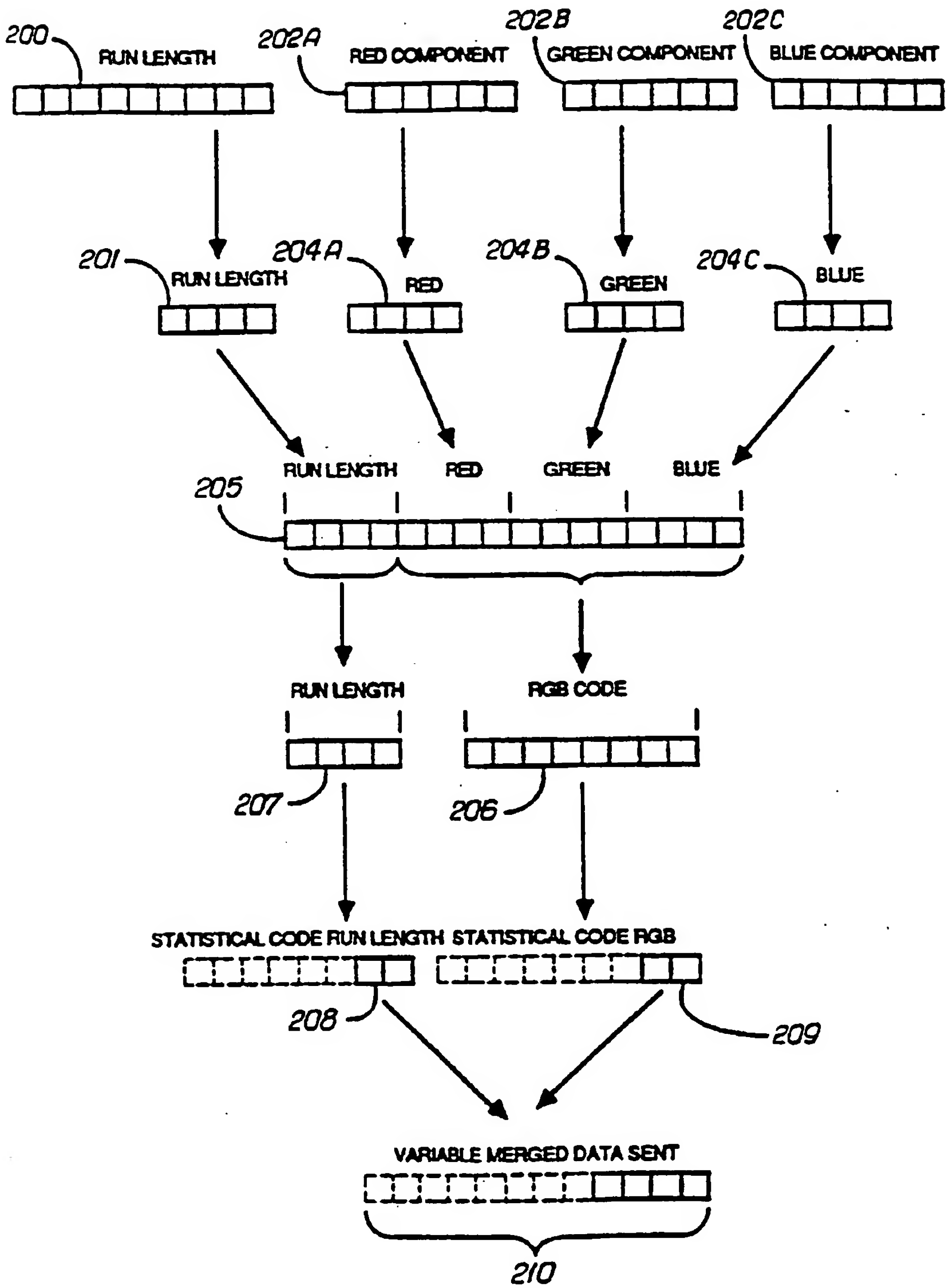
200
RUN LENGTH
202A
RED COMPONENT
202B
GREEN COMPONENT
202C
BLUE COMPONENT
201
RUN LENGTH
204A
RED
204B
GREEN
204C
BLUE
RUN LENGTH
RED
GREEN
BLUE
205
RUN LENGTH
RGB CODE
207
206
STATISTICAL CODE RUN LENGTH
STATISTICAL CODE RGB
208
209
VARIABLE MERGED DATA SENT
210

**FIG. 10**

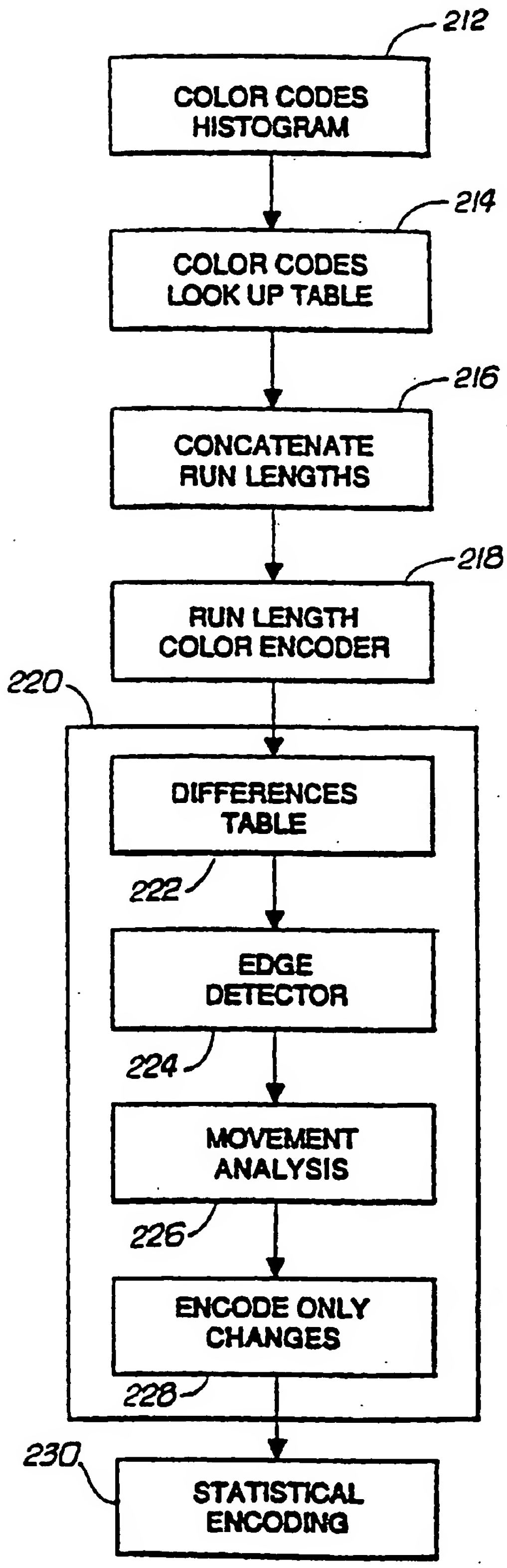
212
COLOR CODES HISTOGRAM
214
COLOR CODES LOOK UP TABLE
216
CONCATENATE RUN LENGTHS
218
RUN LENGTH COLOR ENCODER
220
DIFFERENCES TABLE
222
EDGE DETECTOR
224
MOVEMENT ANALYSIS
226
ENCODE ONLY CHANGES
228
230
STATISTICAL ENCODING

FIG. 11

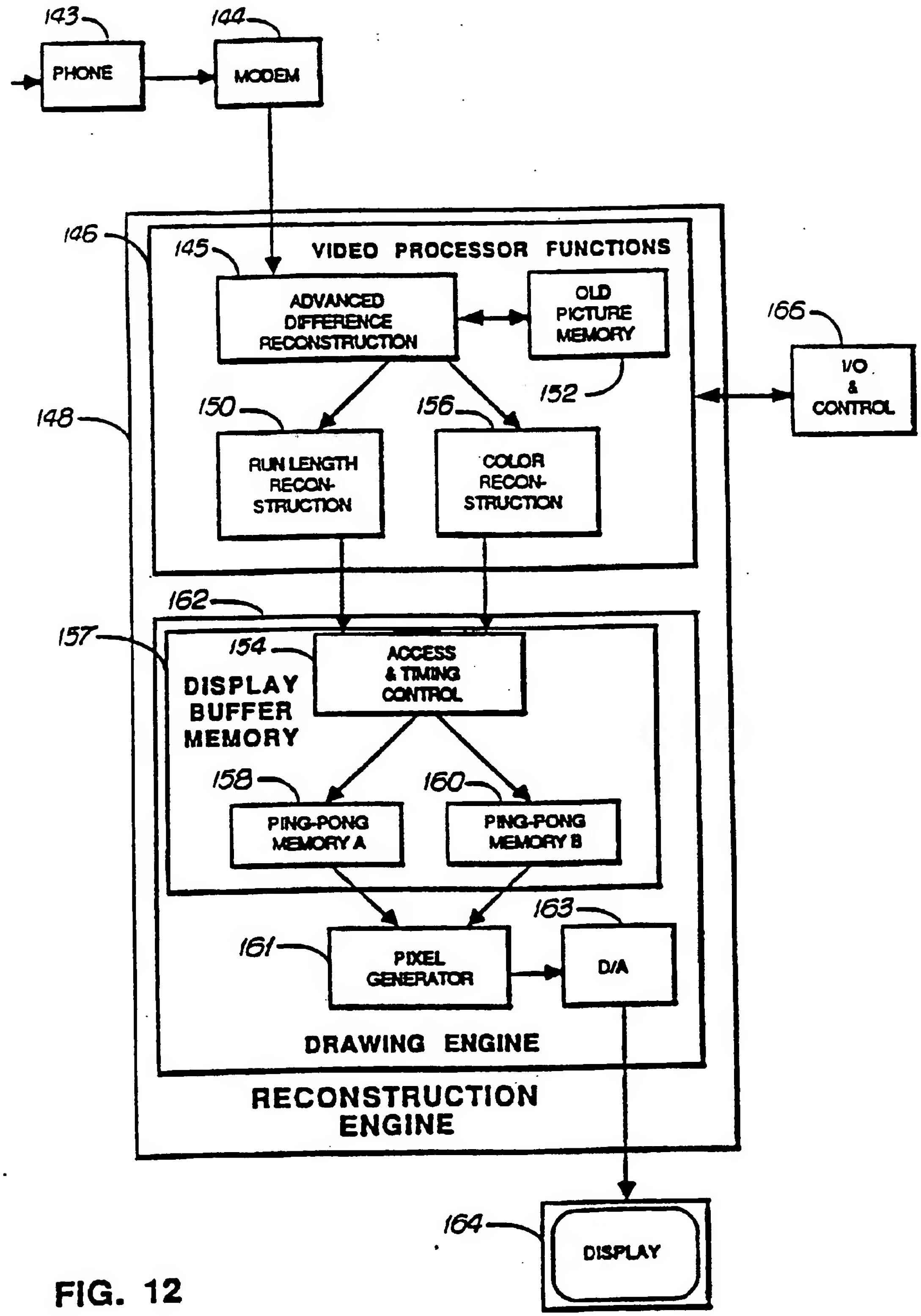
143
144
PHONE
MODEM
146
145
VIDEO PROCESSOR FUNCTIONS
ADVANCED DIFFERENCE RECONSTRUCTION
OLD PICTURE MEMORY
166
I/O & CONTROL
148
150
156
152
RUN LENGTH RECON-STRUCTION
COLOR RECON-STRUCTION
162
157
154
ACCESS & TIMING CONTROL
DISPLAY BUFFER MEMORY
158
160
PING-PONG MEMORY A
PING-PONG MEMORY B
163
161
PIXEL GENERATOR
D/A
DRAWING ENGINE
RECONSTRUCTION ENGINE
164
DISPLAY

FIG. 12

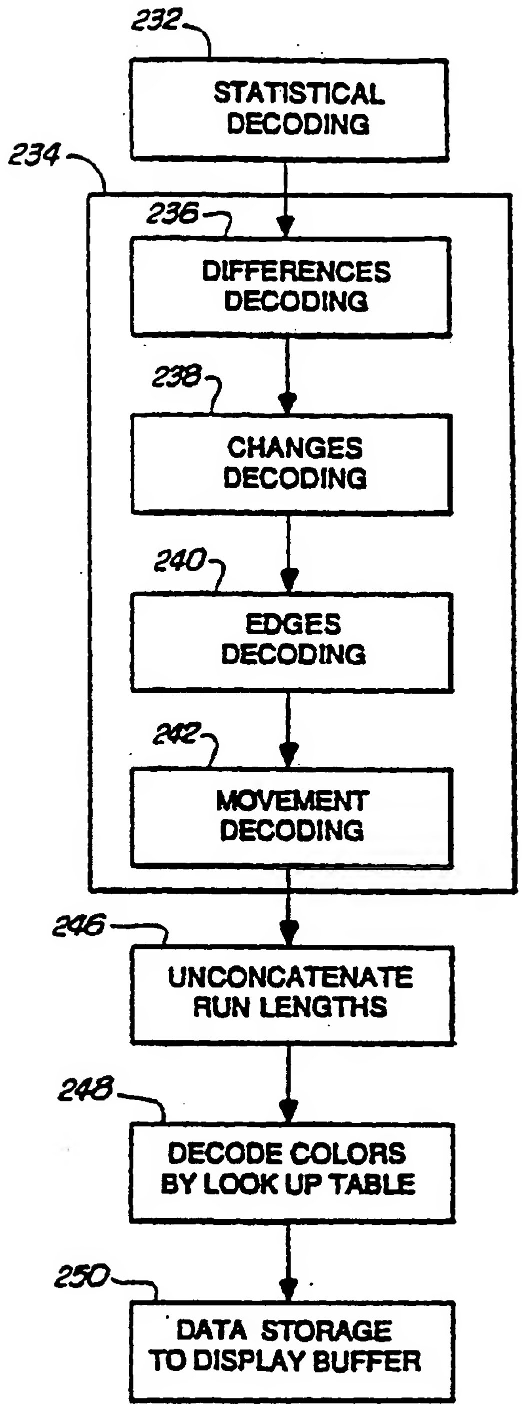
232
STATISTICAL DECODING
234
236
DIFFERENCES DECODING
238
CHANGES DECODING
240
EDGES DECODING
242
MOVEMENT DECODING
246
UNCONCATENATE RUN LENGTHS
248
DECODE COLORS BY LOOK UP TABLE
250
DATA STORAGE TO DISPLAY BUFFER

FIG. 13

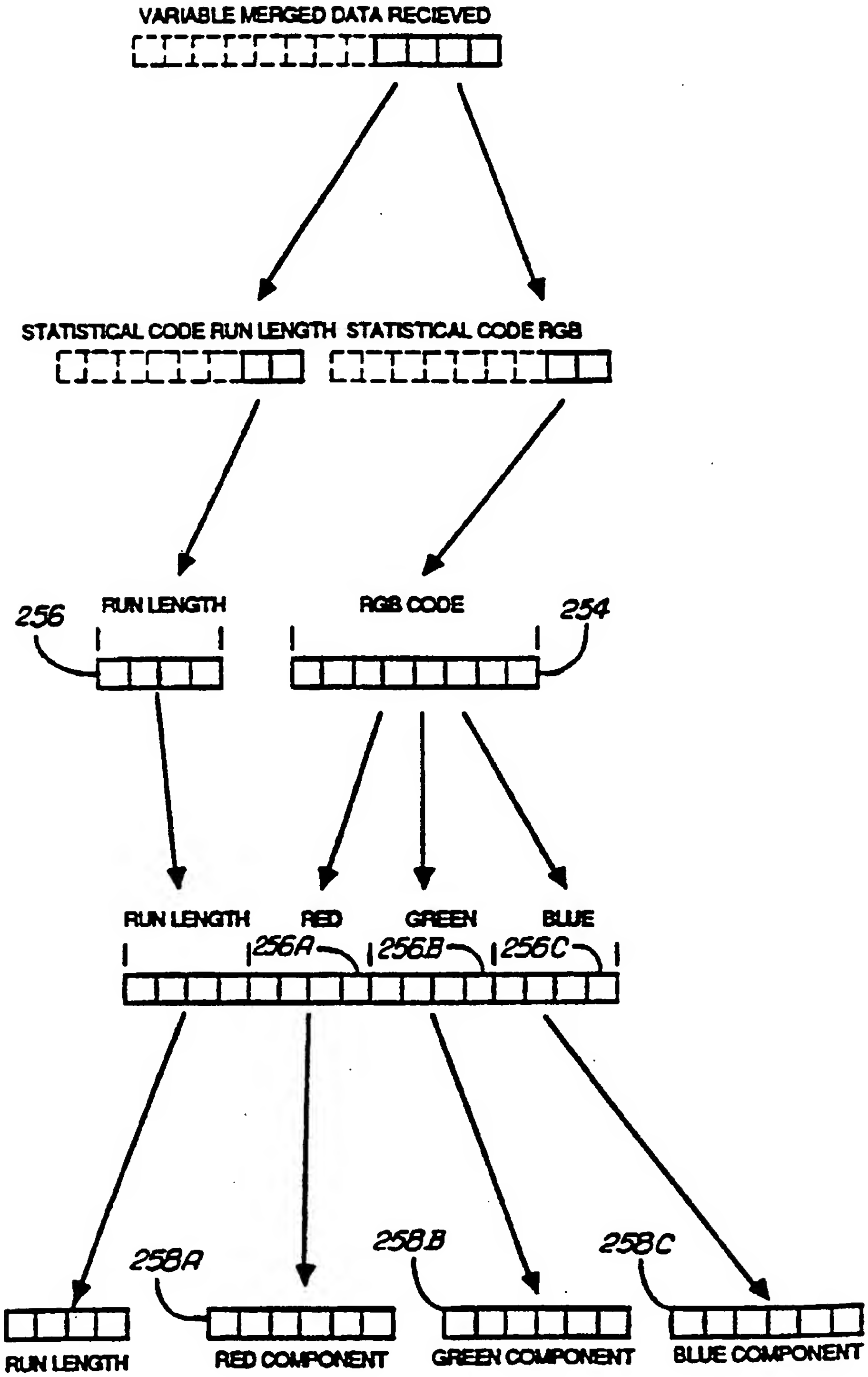
VARIABLE MERGED DATA RECIEVED
STATISTICAL CODE RUN LENGTH
STATISTICAL CODE RGB
256
RUN LENGTH
RGB CODE
254
RUN LENGTH
RED
GREEN
BLUE
256A
256B
256C
258A
258B
258C
RUN LENGTH
RED COMPONENT
GREEN COMPONENT
BLUE COMPONENT

FIG. 14

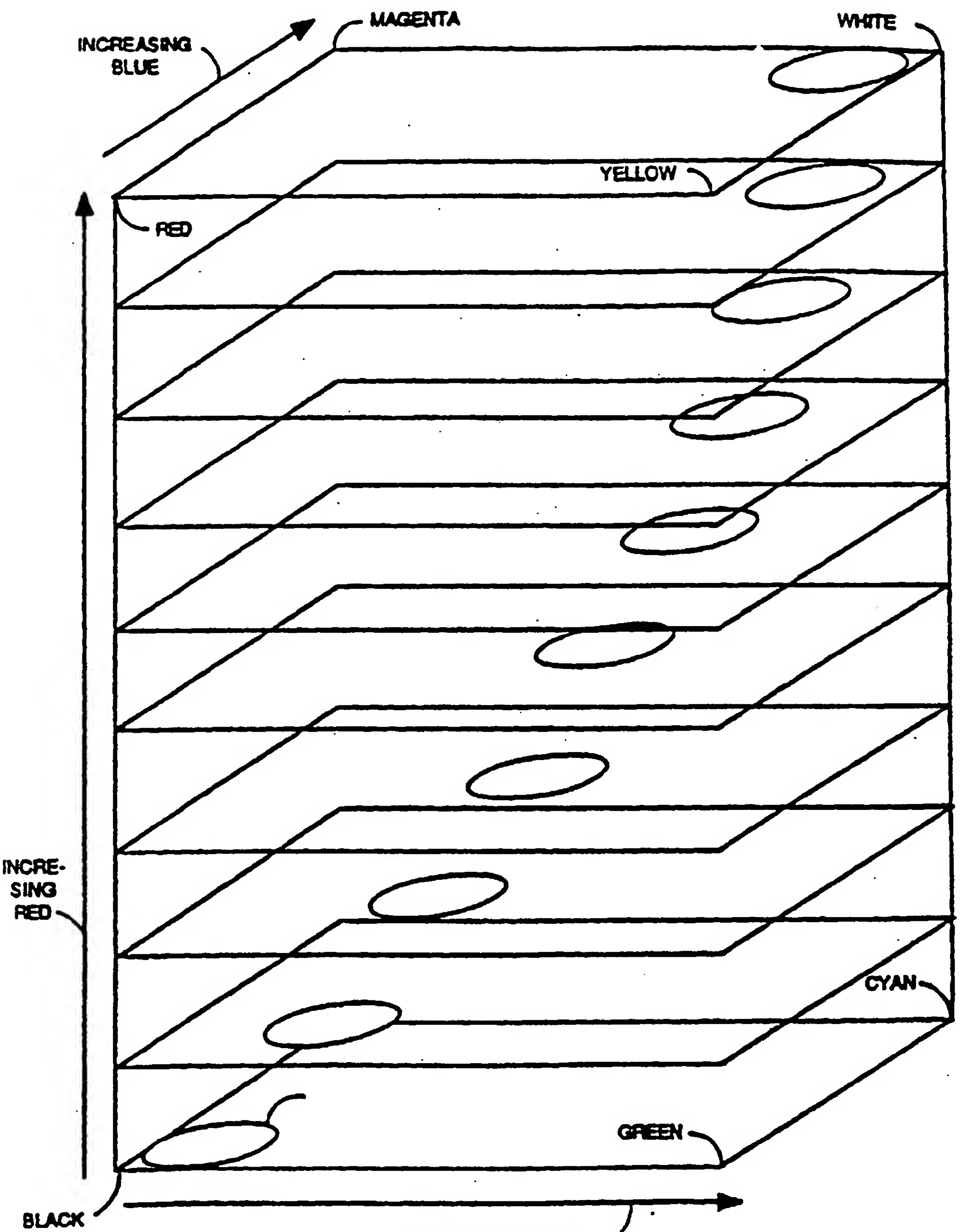
MAGENTA
WHITE
INCREASING BLUE
YELLOW
RED
INCRE-
SING
RED
CYAN
GREEN
BLACK
INCREASING GREEN

FIG. 15